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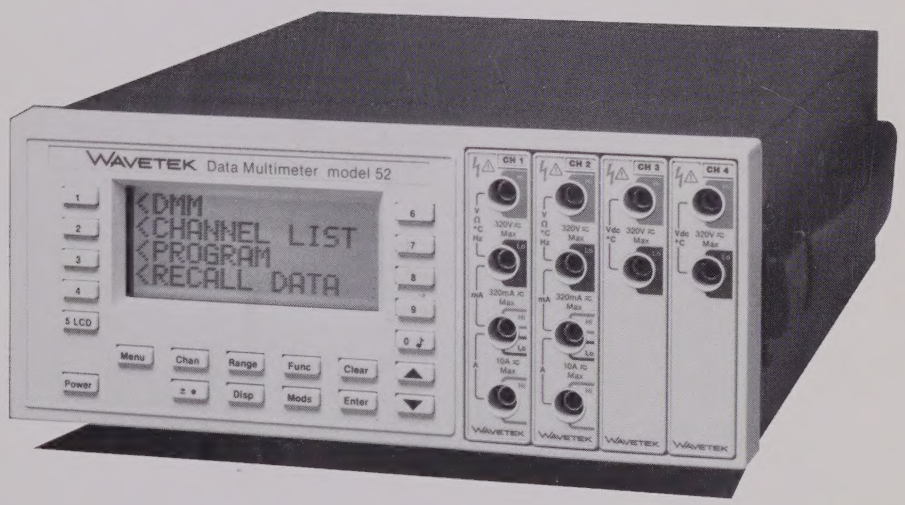

Models 51 and 52
Data Multimeter

Operator's Manual

OPERATOR'S MANUAL

MODELS 51 AND 52
DATA MULTIMETER

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SAFETY

WARNING

The case of the unit is not connected to earth ground through the AC Adapter. The case may inductively or electrostatically float to a high voltage if used in a strong electromagnetic or electrostatic field. This presents the potential for a nasty shock. To prevent this, the case may be connected to earth ground using the uninsulated banana jack ( ) on the rear panel.

Grounds for the Digital I/O, IEEE-488, and RS-232-C cards are connected internally to the case. If one of these grounds in external equipment is connected to earth ground, this will make unnecessary the precautionary connection of the paragraph above, when the unit would have floated electrostatically.

Measurement modules ''float'' to approximately the input common mode voltage. The measurement modules have a shield over their midsection. This shield is connected to analog ground (measurement module input LO). With the case cover off, this shield is exposed. This shield is at input LO potential.

SECTION 1
SPECIFICATIONS

1.1 THE MODEL 52

The Model 52 data multimeter can function as a measuring instrument, data logger, and process controller.

- As a measuring instrument, the Model 52 measures over 24 functions using its independently isolated multimeter channels. These measurements can be displayed on the screen or transmitted from the RS-232-C or IEEE-488 ports.
- As a data logger, the Model 52 stores the measurements in its internal memory. The Model 52 can measure and store measurements from up to 260 inputs. Later on you can recall (display or transmit) the stored measurements.
- As a process controller, the Model 52 makes decisions (alarms) based on the measurements. The actions of the alarms can be used to control external devices.

The Model 52 can be set up locally using the front panel keys or remotely using remote commands via the RS-232-C or IEEE-488 ports.

1.2 Model 51

Model 51 has the same capabilities as Model 52, except it is intended for remote operation only and, therefore, has no front panel keyboard and display.

Table 1-1. Model 52 Features

General	Specific
Modes	DMM: Single channel Digital Multimeter measurements are made (52 only). Channel List/Multiple Channel DMM: Several single channel DMM measurements are made and are continuously updated. Program: Channel List measurements are made with start and stop conditions. Data can be stored or transmitted in all modes.
Functions	Voltage: dc, ac, or ac + dc. Temperature: Thermocouple or cold-junction. Amperes: dc, ac, or ac + dc. Decibels: dB, dBm, dBW, dBdc, or dBac. Power: Watts dc or volt-amperes ac and ac + dc. Resistance Continuity Diode Check Events Counter Logic Level Frequency Period Time Interval: Continuous and one-shot. Pulse Width: Continuous and one shot.
Channels	Measurement Modules (Options 50-1 and 50-2): Channels 1, 2, 3, and 4. Expand to 260 channels using Option 50-20 Multiplexers (64 channels per multiplexer module). (Measurement inputs and control outputs.) Digital I/O Cards (Option 50-14): Channels 5, 6, 7, and 8. User-Defined Math and Text Channel: Channel 0. Time and Date Channel: Channel 9.
Storage	9.6K Bytes (Standard): Approximately 870 readings. 768K Bytes (Optional): Approximately 72,000 readings. Number of readings depends on the size and number of Channel Lists and Programs.

Table 1-1. Model 52 Features (Continued)

General	Specific
Communications	RS-232-C (Standard): Selectable baud rate 300, 1200, 9600, and 76800. GPIB — IEEE-488 (Optional): Full talk and listen capabilities. Selectable device addresses 1 through 15.
Math	Built-in Math Functions: Delta, Delta %, Minimum, Maximum, and Average readings. User-Defined Math Functions: Up to 99 formulas entered from front panel, RS-232-C or GPIB.
Function Modifiers	Function Modifiers alter how measurements are taken and how the Model 52 responds to the measurement. Delay: Readings delayed from 0 to 25.5 seconds (user-selected). Alarms: Up to 31 programmable alarms each with selectable conditions and levels. Active alarms sound tones, initiate programs, or control Digital I/O channels. Track: Digital I/O channel produces a proportional digital byte or analog level output which follows a channel reading. Each output has setable zero and full scale value.
Display Modifiers	Display Modifiers affect how measurements are displayed, transmitted, and stored. Scale: Reading scaled by user-defined formula. See Channels and User-Defined Math. Minimum: Displays the minimum reading. Maximum: Displays the maximum reading. Resolution: Displays bar graphs and selectable resolution. Average: Displays an average of readings (1 to 255 readings averaged). Delta: Displays the deviation relative to the current reading or numeric entry.

1.3 SPECIFICATIONS

Accuracy specifications are for 1 year with an operating temperature of 18° to 28°C (64° to 82°F) and a relative humidity of 80% or less.

1.3.1 Measurement Module

Up to four Measurement Modules can be installed in the Data Multimeter. Each module provides one set of front-panel input connectors and one pair of rear-panel multiplex input connectors. Auto-ranging is standard.

Two Measurement Module versions are available. They may be specified in any combination and channel location, up to a maximum of four.

50-1 Measurement Module: All specifications and functions listed below apply.

50-2 Measurement Module: A lower-cost module limited to dc volts and temperature functions.

1.3.2 Functions

1.3.2.1 DC Volts

Resolution and Accuracy

Range	Resolution For Digits Displayed 2.5	3.5	4.5	Accuracy ±(% of Rdg + % of Rng)	Input Impedance
30 mV	0.1mV	10μV	1μV	0.04 + 0.02	>1000MΩ
300 mV 3 V	1mV 10mV	100μV 1mV	10μV 100μV		
30 V 300 V	100mV 1V	10mV 100mV	1mV 10mV	0.04 + 0.005	10MΩ ± 1% II<50 pF

Resolution vs Data Rate and Noise Rejection (1kΩ Unbalance)

Display Mode	50 – 60 Hz NMR	60 Hz ECMR	50 Hz ECMR	Data Rate
4.5 digits	70 dB	150 dB	145 dB	5/sec
3.5 digits	50 dB	130 dB	125 dB	16/sec
2.5 digits	50 dB	130 dB	125 dB	16/sec

System Throughput: 20 channels/sec.

Maximum Input Voltage: ±450 Vdc or peak ac continuous. Inputs protected against 6 kV transients less than 10μs wide. Maximum voltage to chassis ground: ±500 V peak.

1.3.2.2 AC Volts

(RMS AC and RMS AC + DC)

Accuracy (AC Coupled)

			Accuracy ±(% of Rdg + % of Rng)					
			For Frequency Ranges (Hz)					
Range	Max Res	Input Voltage	20-45	45-10K	10K-30K	30K-100K	100K-.3M	.3M-1M
30mV	1μV	3-32mV	1 + 1	5 + 1	1 + 2	3 + 2	5 + 5 Typ	*
300mV 3V 30V 300V	10μV 100μV 1mV 10mV	30-320mV .3-3.2V 3-32V 30-320V	1 + .04	5 + 04	1 + .07	2 + 1	3 + 2	5 + 5 Typ

*Not specified

AC + DC Accuracy: Add 2% of range to the ac coupled specifications.

Input Impedance: 1 MΩ shunted by less than 50 pF.

Crest Factor: Up to 3 for rated specifications. Up to crest factor 11 achievable at 1/3 scale with 2% additional error.

CMRR: >60 dB at 50 or 60 Hz (1 kΩ Unbalance).

Maximum Input Voltage: Same as DC Volts except 20 sec max on the 3 V, 300 mV, and 30 mV ranges. Volt-Hertz product $\leq 10^7$.

1.3.2.3 Decibel (dB)

Relative dB, dBm, and dBW measurements are calculated in software. Measurements assume the reference load is external and are made in a two-wire bridging mode.

Reference Impedances

dBm: 50Ω, 75Ω, 90Ω, 93Ω, 115Ω, 125Ω, 135Ω, 150Ω, 250Ω, 300Ω, 500Ω, 600Ω (default), 600Ωrn, 800Ω, 900Ω, 900Ωrn, 1000Ω (dBV), 1200Ω.

dBW: 2Ω, 4Ω, 8Ω (default), 16Ω.

dBdc

Linear Counts	Resolution dB	Accuracy ±dB
>1024	01 dB	04 dB
256 – 1024	.1 dB	.2 dB
16 – 256	1 dB	1 dB
<16	—	Not Specified

dBac

		Accuracy For Any Ref Z (±dB)					
		For Frequency Range (Hz)					
dBm (Ref 600Ω)	dBW (Ref 8Ω)	20-45	45-10K	10K-30K	30K-100K	100K-.3M	.3M-1M
– 68 to – 48	– 81 to – 59	1		1 5	2	Not Specified	
– 48 to – 28	– 59 to – 39	0 2	0 15	0 25	0.5	0 8	
– 28 to – 8 – 8 to + 12 + 12 to + 32 + 32 to + 52	– 39 to – 19 – 19 to + 1 + 1 to + 21 + 21 to + 41	0.15 0 10	0 10 0.07	0 15 0 10	0 30 0 20	0.50 0 35	1 00

Underlined specifications apply to 1/3 scale and above

1.3.2.4 Temperature

Thermocouple linearizations provided by software for types J, K, E, and T. Cold-junction temperature is available to calculate temperature from other types of thermocouples.

Accuracy

		Temperature Range		Accuracy ±°C/°F	
TC Type	Res	°C	°F	24 Hr*	1 Yr
J	0 1°	– 200 to 0° 0 to 760°	– 328 to 32° 32 to 1400°	0.3°/0.5° 0.2°/0.4°	0 5°/0 9°
K		– 200 to 0° 0 to 1370°	– 328 to 32° 32 to 2500°	0.3°/0.5° 0.2°/0 4°	
E		– 250 to 0° 0 to 1000°	– 418 to 32° 32 to 1832°	0.3°/0.5° 0.2°/0 4°	
T		– 230 to 0° 0 to 400°	– 382 to 32° 32 to 752°	0.3°/0.5° 0.2°/0 4°	

*This accuracy can be restored at any time with the Cal 0 modifier

1.3.2.5 Cold Junction Temperature

Readable at 2° to + 70°C ±0.4°C with 0.01° resolution. Can be used to determine ambient temperature with no TC attached. Useful for linearizing TC's not covered by the built-in linearization tables. Separate cold junction readings are found on each multiplexer.

1.3.2.6 Ohms

Measurements are made two-terminal from the front inputs or four-terminal using the front panel inputs to source and the rear panel inputs to sense.

Resolution and Accuracy

Range	Resolution For Digits Displayed 2.5	3.5	4.5	Accuracy ±(% of Rdg + % of Rng)	FS Vout	I OUT
30 Ω	0.1Ω	10mΩ	1mΩ	0.08 + 0.02	30mV	1mA
300 Ω	1Ω	100mΩ	10mΩ		.3V	1mA
3 kΩ	10Ω	1Ω	100mΩ		3V	1mA
30 kΩ	100Ω	10Ω	1Ω	0.07 + 0.005	3V	100μA
300 kΩ	1kΩ	100Ω	10Ω		3V	10μA
3 MΩ	10kΩ	1kΩ	100Ω	0.1 ± 0.01	3V	1μA
30 MΩ	100kΩ	10kΩ	1kΩ	0.15 + 0.02	3V	0.1μA

Open Circuit Voltage: < +10 V @ 1 mA or less.

Overload Protection: 280 Vrms or ±400 V peak continuous.

1.3.2.7 High Megohms

The Models 51 and 52 can measure resistances up to 3200 MΩ's by a process which calculates parallel resistance.

Ranges: 300 MΩ, 3000 MΩ.

Resolution

30MΩ to 100MΩ: 10kΩ.
100MΩ to 320MΩ: 100kΩ
300MΩ to 1000MΩ: 1 MΩ.
1000MΩ to 3200MΩ: 10 MΩ.

Open Circuit Voltage: < +1.1 V @ 100nA or less.

All other **High Megohms** specifications are the same as the **Ohms** specifications.

Accuracy: 5% (below 70% RH).

1.3.2.8 Diode Test

Provides a means of measuring forward biased junction voltage with any of five reference currents.

Range: 0 to 3.2 V.

Test Current Accuracy and Stability

Test Current	Accuracy 1 Year	Stability 24 Hr
1 mA	±1.0%	±0.04%
100 μA	±1.0%	±0.04%
10 μA	±1.0%	±0.04%
1 μA	±1.5%	±0.07%
100 nA	±3.0%	±0.2%

Junction V Accuracy: ±(0.04% Reading + 0.005% Range).

1.3.2.9 Continuity

Range: All Ohms ranges, 3200 count resolution.

Threshold: 3 Ω in the 30 Ω range. 10% of range in all other ranges.

Indication: Internal tone generator, 1kHz. Ohms on display.

Response Time: 50 ms, stretched to 300 ms.

All other **Continuity** specifications are the same as **Ohms** specifications.

1.3.2.10 DC Current

Separate front panel inputs are provided for low current (up to 320 mA) and high current (up to 10 A) measurements. Not available on the MUX/rear panel input.

Resolution and Accuracy

Range	Resolution Digits Displayed 2.5	3.5	4.5	Accuracy ±(% of Rdg + % of Range)	MAX V Burden
30 mA	100μA	10μA	1μA	0.07 + 0.02	40 mV
300 mA	1mA	100μA	10μA	0.07 + 0.005	400 mV
3 A	10mA	1mA	100μA	0.1 + 0.02	150 mV
10 A	100mA	10mA	1mA	0.1 + 0.005	500 mV

Overload Protection: 300 mA fuse (3AG) fuse protects the low current input. The 10 A input is unfused. Up to 30 A can be measured for a maximum of 20 sec before any damage is sustained.

1.3.2.11 AC Current

(True RMS, Shunt DC Coupled)

AC Current specifications are the same as **DC Current** specifications except:

Accuracy

Range	Accuracy ±(% of Rdg + % of Range) 20-45	45-1K	1K-10K	10K-30K	Max V Burden
30 mA	1+0.3	0.5+0.3	1+0.3	5+0.3	40 mV
3 A	1+0.3	0.5+0.3	1+0.3	5+0.3	150 mV
300 mA	1+0.04	0.5+0.04	1+0.04	5+0.1	400 mV
10 A					500 mV

AC+DC Current: Add 1% of range to above specifications.

1.3.2.12 Frequency

Frequency is measured by a period average counting method allowing high resolution and rapid update rates. Resolution is 6 digits per 1.3 sec. Typical frequency response to 8MHz (4 MHz guaranteed).

Accuracy and Resolution

Range	Accuracy	Maximum Resolution
10 Hz		0.000001 Hz
100 Hz		0.00001 Hz
1 kHz		0.0001 Hz
10 kHz	0.0025%	0.001 Hz
100 kHz		0.01 Hz
1 MHz		0.1 Hz to 300k
4 MHz		1 Hz to 1M

Sensitivity, AC Coupled Mode

		Sensitivity Degradation For Frequency Range (Hz)				
Sens AC Coupled	Trigger Level	10-100K	100K-500K-	500K-1M	1M-4M	Max In Vrms
3mV	± 4mV	None	Not Specified			50 mV
30mV	± 40mV					500 mV
300mV	± 400mV		– 5%			5V
3V	± 4V			– 10%	– 20%	50V
30V	± 40V					320V

Sensitivity, DC Coupled Mode

Sens DC Coupled	Threshold + Trig	Threshold – Trig	1-100K	100K-500K	500K-1M	1M-4M	Max In ± Vpeak
TTL	+ 2V	+ 0 8V	None	– 5%	– 10%	– 20%	8V
CMOS 5	+ 3 5V	+ 1 5V					8V
CMOS 12	+ 8V	+ 4V					400V
+ 75mV	+ 100mV	+ 50mV					8V
± 400mV	+ 400mV	– 400mV					8V
± 80V	+ 80V	+ 40V					400V

1.3.2.13 Events

Count Rate: 0 to 800 kHz.

Capacity: 0 to 9,999,999 counts.

Triggering: Positive or negative edge, selectable.

All other **Events** specifications same as the **Frequency** specifications.

1.3.2.14 Period

Resolution and Accuracy

Range	Resolution	Maximum Reading	Units	Accuracy
100 µs	10 ps	100.00000	µs	± 100 ps
1000 µs	100 ps	1000.0000	µs	± 100 ps
10 ms	1 ns	10.000000	ms	± 1 ns
100 ms	10 ns	100.00000	ms	± 10 ns
1000 ms	100 ns	1000 0000	ms	± 100 ns

All other **Period** specifications same as the **Frequency** specifications.

1.3.2.15 Pulse Width, Time Interval

Time intervals measures the time from a positive or negative edge of the front panel or multiplexed input to the negative edge of an optional Digital I/O input.

Resolution and Accuracy

Range	Resolution	Maximum Reading	Units	Accuracy
100 ms	1 µs	100.000	ms	± 2 µs
1000 ms	1 µs	1000.000	ms	± 2 µs
10 s	1 µs	10.000000	s	± 2 µs
100 s	10 µs	100 00000	s	± 10 µs
360 s	100 µs	360.0000	s	± 100 µs

Triggering: Positive or negative edge, selectable.

All other **Pulse Width, Time Interval** specifications same as the **Frequency** specifications.

1.3.2.16 Logic

Provides an easy check of logic levels and activity.

Indication: '1', '0'.

Trigger Levels

Logic Family	DC Threshold + Trig	DC Threshold – Trig
TTL	+ 2V	+ 8V
CMOS 5	+ 3 5V	+ 1 5V
CMOS 12	+ 8V	+ 4V

1.3.2.17 AC Volt-Amperes, DC Watts

The Models 51 and 52 measures volt-amperes ac or watts dc by taking alternate readings of current and voltage and multiplying them together. When setting a range both the voltage range and current range are selected separately. The current and voltage inputs are hooked up simultaneously and both must sense relative to the current low input. VA ac and watts dc are available only on the front panel inputs.

Range and Resolution

Current Range	V Range 32 V	V Range 320 V	Resolution 9999999	Resolution 999999	Resolution 99999	Max VA
320 mA	X	—	1µW	10µW	100µW	10
320 mA	—	X	10µW	100µW	1mW	100
3 2 A	X	—	10µW	100µW	1mW	100
3 2 A	—	X	100µW	1mW	10mW	1k
10 A	X	—	100µW	1mW	10mW	320
10 A	—	X	1mW	10mW	100mW	3 2k

Accuracy: Equal to the accuracy of the volts input plus the accuracy of the current input.

Overload: Equal to the ratings of the respective volts and current ranges.

1.3.3 Function Modifiers

1.3.3.1 Delay

User programmable delays can be inserted in front of any function to allow measurements of slow settling signals.

Range 0 to 25.5 sec in 0.1 sec intervals.

1.3.3.2 Track

The Track function causes the voltage output of the D/A converter on the optional I/O plug-ins to track the channel reading. Full scale and zero settings of the converter are specified on the Track main menu selection.

1.3.3.3 Alarms

Up to 31 alarms are user programmable. Each alarm can have up to two setpoints allowing window comparisons or out of limits alarms. By calling multiple alarms any channel could have up to 62 different alarm thresholds assigned to it. Combined with a Digital I/O option the alarms can be used in control applications. Alarm programming is an easy menu guided procedure.

Alarm Modes: The alarm response is triggered when: $X \geqslant T1$, $X \leqslant T1$, $X \leqslant T1$ or $X \geqslant T2$ (out of limits), $T1 \leqslant X \leqslant T2$ (X is channel data and T1 and T2 are user entered thresholds). The response can be latched on if desired.

Alarm Responses: When an alarm is triggered the response is programmable to any or all of the following: Tone (up to nine distinct sounds user selectable). Store and/or transmit the reading with the alarm number. Store and/or transmit the reading, alarm number and time. Store and/or transmit all the current scan data with time. Store and/or transmit the alarm number. Output a digital word in any desired pattern to any digital I/O board. Output a single bit. Output an analog voltage.

In addition to the above alarm responses, the user can cause a channel list or program to be started as a result of an alarm. Therefore any analog parameter can be used to trigger a new set of data to be looked at, or when a given parameter is exceeded, data can be stored on up to 252 channels to determine what caused the alarm to be triggered.

1.3.4 Display Modifiers

1.3.4.1 Delta

When the Delta modifier is applied, either the current reading or a numeric entry can be used to offset the displayed data.

Indication: $+\Delta$ or $-\Delta$ displayed in front of the reading. "D" is transmitted in data modes.

Accuracy: $\leqslant$ the sum of the errors of the reference reading and the subsequent readings. In the case of a numeric entry of the Delta offset, the accuracy of the current function/range applies.

Range: $\pm$ 999,999 counts. Any delta reading exceeding this range will cause an "OVRRNG" indication.

1.3.4.2 Delta %

Similar to the Delta modifier except the reading is expressed in Delta % calculated by: displayed reading = 100 (current reading-stored reading)/stored reading.

Range and Resolution: Depends on display resolution.

9999999 or 999999 Resolution: $\pm$ 9999.999 Δ%
(counter functions only).
99999 or 32000 Resolution: $\pm$ 9999.99 Δ% (default).
3200 Resolution: $\pm$ 99999.9 Δ%.
320 Resolution: $\pm$ 999999 Δ%.

1.3.4.3 Min/Max

Stores and displays the minimum or maximum reading and updates the memory and display only when CLEAR is pressed or when the current reading exceeds the stored value (MAX) or when the current reading is less than the stored value (MIN).

1.3.4.4 Average

From 1 to 255 readings can be averaged. The display and memory is updated only when all the readings have been taken and averaged. For example, a 32000 resolution reading (5 readings/sec) averaged for 10 readings will take 2 sec to finish and display the calculated average. A 5 reading running average is always applied to displayed channels unless the average modifier is in use.

1.3.4.5 Resolution

Display resolution is selectable on all functions.

1.3.4.6 Bargraph

A segmented bargraph representation of the measurement is selectable from the RES menu. The display shows the channel number and polarity, but is otherwise unitless (range and function not displayed). A bargraph can be displayed concurrently with the digital display of the same channel which would give range and function information as well as a higher resolution reading. There are two bargraph types available: the Full range Bargraph, and the High Resolution Bargraph.

Full Range Bargraph: Each of 64 segments is equal to 1.66% of range in A/D functions (i.e., 50 mV in the 3V range) or 1.5% in frequency counter functions (i.e., 150 Hz in the 10 kHz range). In the dB function, each segment is equal to 1 dB which wraps around when + or − 66.0 dB (relative to the 0 dB reference) is exceeded.

High Resolution Bargraph: Combined with a 2 significant digit display which counts to ± 32 in A/D functions and ± 99 in frequency functions, each segment in the 50 segment bargraph is equivalent to the remaining maximum number of counts divided by 50 (i.e., each segment is equal to 20 counts compared to the 32000 or 99999 resolution mode). This bargraph wraps around each time the 2 significant digits advance or decrease their count.

Display Rate: Dictated by the base function data rate. In Volts dc 16 readings/sec are possible if the 3200 resolution is used for any digital display of the same data.

1.3.5 Data Logging Functions

Models 51 and 52 Data Multimeters support a number of data logging modes. Data can be gathered continuously or at user defined scan intervals and logged into memory or sent out the Comm port (either RS-232-C or IEEE-488). All setups are menu driven and no programming language is required.

1.3.5.1 Channel Lists

A group of channels are organized into "Channel Lists" that predefine channel function, range, and any modifiers such as deltas, alarms, averaging, etc. Each channel list is assigned up to an eight character name for later recalling. Channels can be entered individually or as groups. When entering a channel group, the function, range and modifiers can be entered once for the entire group thus speeding entry of long channel lists. Up to 255 lists of up to 64 entries each may be defined. User Channel Lists are found on the main menu and are distinguished with a **.L** suffix. Once a channel list is entered it can be run to verify that it functions as desired. Channel lists are used in the program mode to define what data is logged.

1.3.5.2 Programs

Programs are defined as a framework for data logging. A program consists of a user defined program name, a start condition, a scan interval, a stop condition, an end condition and one or more channel lists. In addition each channel list can be repeated up to 98 times within a given scan interval allowing uneven "weighting" of stored data. Programs, once entered, are found on the main menu and are distinguished with a **.P** suffix.

Start Program Modes:

- Start immediately.
- Start at a time expressed in Δ days (up to 99) and real time in hours and minutes.
- Start at a delta time from the push of the run softkey expressed in DD HH:MM.
- Start when any of 36 input triggers (Option 50-14 Digital I/O) change states, positive or negative level triggering user selectable.

Scan Interval: Programmable in 1 sec increments from 1 sec to 99 days, 23 hr and 59 sec in a DD HH:MM:SS entry sequence. The scan interval can also be disabled allowing continuous data logging.

Stop Program Modes:

- Stop at a time expressed in Δ days (up to 99) and real time in hours and minutes.
- Stop at a delta time from program start (DD HH:MM).
- Stop when any of 36 triggers change state (Option 50-14 Digital I/O).
- Stop after 1 to 9998 scans have been made.
- Stop when the internal memory is full.
- Stop manually from the keyboard or over the Comm port.

End Programming: When the specified stop condition is met the Models 51 and 52 can be set up to start another program thus allowing the chaining of programs. This feature allows nested programs that take data at differing scan rates.

1.3.5.3 Monitor Mode

The monitor mode defines what the Data Multimeter does in between scans. There are three monitor modes available:

- Display the time until the next scan; both the real time and a count down timer are displayed.
- Power-down between scans to conserve battery life.
- Run a monitor channel list. Any predefined channel lists can be scanned between data scans. Alarms are still active and can be used to jump out of the current program and change to a new program. This features allows full time process control with intermittent data logging.

1.3.6 General

1.3.6.1 RS-232-C Serial Port

Connector: DB-25 (female) on rear panel with DCE or DTE configuration user selectable by internal header.

Mode: Full duplex with CTS/RTS or XON/XOFF handshaking.

Data Format: 8 bits, no parity, one stop bit.

Data Rate: 300, 1,200, 9,600 and 76,800 baud, user selected by rear panel switch or by menu.

1.3.6.2 Display

32 by 84 dot matrix liquid crystal graphics display. Full annunciation of channel, range, mode, and function is available on all displayed channels. (Model 52 only.)

1.3.6.3 Isolation

The Models 51 and 52 chassis common is fully isolated from earth ground but common to RS-232-C or IEEE-488 ground. A banana jack connected to chassis common is provided to ground the chassis if so desired.

Input Low to Chassis Common: ± 500 V peak max.

Channel Low to Any Other Channel Low: ± 500 V peak max.

Chassis Common to Earth Ground: ± 500 V peak max. (AC transformer connected; no earth connections through I/O. RS-232-C, or IEEE-488).

1.3.6.4 Data Memory

Up to 870 readings can be stored in unexpanded Models 51 and 52. Actual storage capability depends on the number of channels entered as the resident channel list, and the number of stored channel lists and programs. Memory can be expanded up to .8 megabytes allowing a maximum of ≈72,000 stored readings.

1.3.6.5 Environmental

Operating Temperature

Model 51: 0° to 70°C,
Model 52: 0° to 50°C.

Storage Temperature

Model 51: −40° to 80°C,
Model 52: −20° to 70°C.

1.3.6.6 Temperature Coefficient

For operating temperatures <18°C or >28°C multiply the applicable accuracy specification times 0.1 per °C.

1.3.6.7 Humidity

≤70% RH to 50°C, ≤80% RH to 35°C, except on the 3MΩ, 30MΩ, 300MΩ, and 3000MΩ ranges: ≤70% RH to 35°C.

1.3.6.8 Power

Standard

52−110v Wall Supply: 90 to 132 Vac, 50/60 Hz ≤16VA.

52−220v Wall Supply: 180 to 260 Vac, 50/60 Hz ≤16VA.

External Power

Any dc source from ± 8 to 24V or any isolated ac source from 6 to 20V can be used to power the Models 51 and 52. Current drain ranges from 10μA at standby to 0.5A running an IEEE-488 option. Maximum drain without IEEE-488 is 300mA with all four channels running any of the ac functions. Typical drain is ≈100mA.

When the internal battery option is installed, the power will automatically switch to the battery option if the line input fails or falls below 7.5V (6 Vac).

1.3.6.9 Physical

Size: 21.5 cm (8.5 inch) wide w/o handle. 22.6 cm (8.9 inch) with handle; 8.8 cm (3.5 inch) high w/o feet. 10.8 cm (4.0 inch) with feet; 30.7 cm (12.1 in.) deep.

Weight:

Net: 3.3 kg (7.25 lb) plus 0.45 kg (1 lb) Wall Transformer. Option 50-11 Battery adds 1.47 kg (3.25 lb).

Shipping: 4.4 kg (9.7 lb). Option 50-11 Battery adds 1.47 kg (3.25 lb).

1.3.6.10 Scale/Math Channel 0

All channels can be scaled by a user constant or by another channel's data allowing interactive display of complex measurements. Up to 99 formulas (Chan 0_{01} to Chan 0_{99}) can be entered directly with the keyboard or via the RS-232-C or IEEE-488 ports. Typical applications include scaling transducers, efficiency measurements, and ratio calculations.

Math Functions: +, −, ×, ÷, √, (, and).

Labels: Up to four alpha characters can be defined per Math channel, allowing custom labels or units to be displayed. For example 'PSI' could be entered for the current output of a pressure transducer.

1.3.7 Options

1.3.7.1 Option 50-1 Measurement Module

Up to four Option 50-1 measurement modules can be installed in the Models 51 and 52. Each module provides one set of front-panel input connectors and one pair of rear-panel multiplex input connectors. All functions described in paragraph 1.2.2 apply to the Option 50-1 measurement module.

1.3.7.2 Option 50-2 Measurement Module

Up to four Option 50-2 measurement modules can be installed in the Models 51 and 52. Each module provides one set of front-panel input connectors and one pair of rear-panel multiplex input connectors. Option 50-2 measurement module measures dc volts, dBdc, and temperature. (Refer to paragraph 1.2.2.)

1.3.7.3 Option 50-10 Primary Cell Battery

Battery Type: 8 alkaline 'C' cells (not included).

Approximate Continuous Operating Time: Up to 100 hr depending on channel and function configuration.

1.3.7.4 Option 50-11 Rechargeable Battery Option

The Option 50-11 option provides a rechargeable battery and charging circuitry. Charging is in three phases; a bulk charge, overcharge, and trickle charge. This advanced charging method provides a fast charging rate and long battery life.

Battery Type: 12 V, 2.9 AH sealed lead acid (provided).

Charging Time:

From Deep Discharge to Full Charge: 12 hr.
From 1/2 Discharge to Full Charge: 4 hr.

Approximate Continous Operating Time: Up to 70 hr depending on channel and function configuration.

1.3.7.5 Option 50-12-X RAM Expansion Board

Expands data and program memory. In direct data storage, each 128K of expansion memory adds approximately 12,000 data points. Models 51 and 52 can hold up to 3 RAM boards (excluding other option boards) each of which can hold up to 256 kbytes. The RAM is backed up when the battery option is installed or while any power is available through the rear panel.

50-12-128: 128K RAM Expansion Board.
50-12-256: 256K RAM Expansion Board.

1.3.7.6 Option 50-13 IEEE-488 Option Board

GPIB Option follows IEEE-488-1978 conventions. Full talk and listen capability.

Port Interface: Isolated from A/D channel cards, common to chassis ground, doubled buffered.

Address: 0 to 30, internal switch selected on initial power up, software selectable via front panel.

Subsets: SH1, AH1, T6, TE0, L4, SR1, RL1, PP0, DC1, C0, E1.

Power: Requires 7 to 20 V ac or dc @ 500 mA. Must be supplied externally either by the standard wall transformer or by an external battery. Will not run from the internal battery option. For external battery operation without GPIB (to preserve battery life), a switch is provided to turn off the GPIB board.

1.3.7.7 Option 50-14 Digital I/O + Analog Out Board

Provides 8 bits of digital read, 8 bits of digital write, and an 8 bit digital to analog converter for monitor and control applications. This option board is fully isolated from the 4 A/D channels and is common to chassis ground. Mating connector included.

Digital Output Section: Open drain outputs can be used to switch up to 50 Vdc @ 250 mA. (These outputs are typically used to interface to relays, digital logic, motor controllers, alarm lamps and bells, control valves, and anything else that can be controlled by a logic switch.) The outputs are lightly pulled up to + 5 Vdc and can be used to interface directly with 5 V logic at slow data speeds (100 bits/sec). Higher speed switching is possible by externally pulling up the output with a lower value resistor (1kΩ or greater). The outputs should not be pulled more than 0.6 V below chassis/circuit ground.

Maximum Voltage: + 50 Vdc.

Maximum Current Sink: 250 mA.

Current Source: 100kΩ pullup to + 5 V.

Digital Input Section: The digital read inputs are parallel polled under program control at up to a 20 ms rate. All eight inputs can be used as triggers or to read contact closures and can be read independently, or masked and read in any combination. The inputs are lightly pulled up (normally high) for reading contact closures to ground.

Logic 0: + 0.9 V max, − 50 V min.

Logic 1: + 3.2 V min, + 50 V max.

Logic Polarity: Fully programmable.

Min Input Current: 50 μA sink, 0 source (internally pulled up).

Protection: Protected against inputs up to 125 Vrms.

Analog Output Section: The analog output provides a controllable dc voltage for proportional control, driving chart recorders, and anything else requiring a linear output voltage.

Range: 0 to + 2.55 V in 256 steps.

Resolution: 10 mV/bit.

Accuracy: ± 1.5 bits at full scale, ± 0.5 bits relative.

Source Current: + 5 mA max.

Protection: Short circuit proof, momentary short to + 5 V.

1.3.7.8 Option 50-20 8/16 Channel HI-V Multiplexer With Thermocouple Compensation

The Option 50-20 is used to multiplex input signals to the Models 51 and 52 thereby expanding the total channel count. One Option 50-20 will expand an A/D channel to 16 inputs single ended or 8 channels differential (internally selectable).

Maximum Input V: ± 300 Vdc or peak ac between any two input terminals. Transient protected to 6kV peak <10μs.

Maximum Current: ± 180 mA peak single ended, ± 140 mA peak differential.

Thermal EMF: ⩽400 nV single ended, ⩽800 nV differential.

Closed Channel Resistance: From 0 to 50°C; ⩽60 Ω single ended, ⩽120 Ω differential.

Open Channel Leakage Current: 0.5 nA.

Functions: All Models 51 and 52 functions are supported except current and VA. (Each channel can be fitted with a shunt for current measurements, including 4 to 20 mA loops.) Ohms requires the addition of a parallel 50-20 multiplexer to switch the test current (4 terminal). Degrade ac specifications by 1.00% and limit bandwidth to 100 kHz.

1.3.8 Accessories

1.3.8.1 Accessory 50-30 Extra Lead Set

Each Model 51 or 52 is shipped with a deluxe test lead set consisting of a safety designed pair of test leads 48 inches long, 2 screw on alligator clips, 2 spring hook adaptors, spade lugs, and tip covers. Extra test lead sets are available by ordering Option 50-30.

1.3.8.2 Accessory 50-31 Soft Carrying Case

Versatile, rugged, and handsome soft carrying case for the Model 51 or 52 for field or portable applications. Has space for the manual, test leads, optional multiplexers, wall transformer and more. Comes with a shoulder strap and handles.

1.3.8.3 Accessory 50-32 Digital I/O and Analog Output Breakout Module

Accessory 50-32 Digital I/O and Analog Output Breakout Module provides convenient terminal strip connections for Digital I/O channels.

1.3.9 Configuration Matrix

System Configuration	Option Position				
	Internal	Rear Panel			
	J11	8	7	6	5
3 RAM	R	▨	R	▨	R
2 RAM	R			▨	R
1 RAM	R				
2 RAM 1 I/O	R	▨	R		I
2 RAM 2 I/O	R	▨	R	I	I
2 RAM 1 I/O GPIB	R	G	▨	R	I
2 RAM GPIB	R	G	▨	R	
1 RAM 4 I/O	R	I	I	I	I
1 RAM 3 I/O	R		I	I	I
1 RAM 2 I/O	R			I	I
1 RAM 1 I/O	R				I
1 RAM GPIB 1 I/O	R	G			I
1 RAM GPIB 2 I/O	R	G		I	I
1 RAM GPIB 3 I/O	R	G	I	I	I
GPIB		G	▨	▨	▨
GPIB 4 I/O	G	I	I	I	I
GPIB 3 I/O		G	I	I	I
GPIB 2 I/O		G		I	I
GPIB 1 I/O		G			I
4 I/O	▨	I	I	I	I
3 I/O	▨		I	I	I
2 I/O	▨			I	I
1 I/O	▨				I

R = RAM Board Option 50-12-XXX
G = GPIB (IEEE-488) Interface Option 50-13
I = Digital I/O Board Option 50-14

▨ = Position Can Not Be Used.
□ = Alternate position in some cases but not all.

1.4 ITEMS FURNISHED

Each Model 51 or 52 is shipped with an instruction manual, one set of test leads (Accessory 50-30), and wall supply.

SECTION 2
PREPARATION FOR USE/INSTALLATION

2.1 RECEIVING AND INSPECTING SHIPMENTS

Use the following steps to inspect a shipment of Wavetek equipment.

1. **Inspect the shipment.** Before unpacking the Model 52 your receiving clerk should have checked the shipment for missing boxes and inspect each box for damage and, if necessary, have had the driver describe the box damage and list shortages on the delivery bill. If you find unreported shortage or damage, notify the shipper before further unpacking.
2. **After unpacking the boxes.** Save all the packing material.
3. **Inspect the equipment for damage.** Inspect it carefully, regardless of the condition of the shipping boxes.
4. **If necessary, file a damage claim.** If any damage is found, call the shipper immediately (within 10 days) and start the claim process.
5. **Call Wavetek.** Call Wavetek's Customer Service department (619-279-2200) and tell them that the equipment arrived damaged.

2.2 RETURNING EQUIPMENT FOR REPAIR

Use the following steps when returning Wavetek equipment to Wavetek for repair.

1. **Save the packing material.** Always return equipment to Wavetek in its original packing material and boxes. If you use inadequate packing material, you will have to pay to repair any shipping damage as carriers will not pay claims on incorrectly packed equipment.
2. **Call Wavetek for a Return Authorization.** Wavetek's customer service representative will ask for a name of the person returning the equipment, telephone number, company name, equipment type, and a description of the problem.
3. **Pack and ship the equipment.**

2.3 ELECTRICAL INSTALLATION

2.3.1 Power

Power Supplies

Wavetek ships the Model 52 with a power supply to match a user specific line voltage requirements.

90 to 132 Vac, 50/60Hz, ⩽16VA
180 to 260 Vac, 50/60Hz, ⩽16VA

External Supplies

Model 52 may be powered by an external ac or dc source. To connect Model 52 to an external source, use a power connector (female plug; 2.5 mm inside diameter, 5.5 mm outside diameter): Electro-Mech part number 1030-4 or equivalent (available from Radio Shack).

DC source: +8 to +24Vdc
AC source: 6 to 20Vac
Typical drain: approximately 100mA.
Maximum drain (all four channels running without IEEE-488): 300mA.
Standby current: ∼100μA.
IEEE-488 current: approximately 500mA.

CAUTION

When removing or installing option boards inside the Models 51 and 52, you must disconnect external power supplies or sources and internal batteries, otherwise the instrument could be damaged. The lithium RAM battery should not be removed.

To prevent damage to the instrument, check for proper match of line and transformer voltage and proper fuse type and rating.

Batteries

Model 52 can be powered by internal batteries (Options 50-10 and 50-11).

The 50-10 Primary Cell Battery consists of eight alkaline "C" cells (not included). These batteries operate up to 100 hours depending on Model 52 configuration and operating mode.

Battery Replacement. The following procedure describes installation or replacement of Option 50-10 alkaline cells.

1. Remove the top cover; see figure 2-1.
2. Disconnect the battery cable from the Mother Board; see figure 2-2.
3. Open the top cover's battery housing cover (see figure 2-3) and remove the battery holder.
4. Install the eight cells into the battery holder. Ensure the cells are installed in the correct polarity as illustrated on the holder.
5. Rotate each cell inside the holder 1/2 rotation to ensure all contacts are seated and making good connection.
6. Replace the battery holder in the housing and close the housing cover; see figure 2-3.
7. Connect the battery cable to the Mother Board; see figure 2-2.
8. Replace the top cover by reversing the steps shown in figure 2-1.

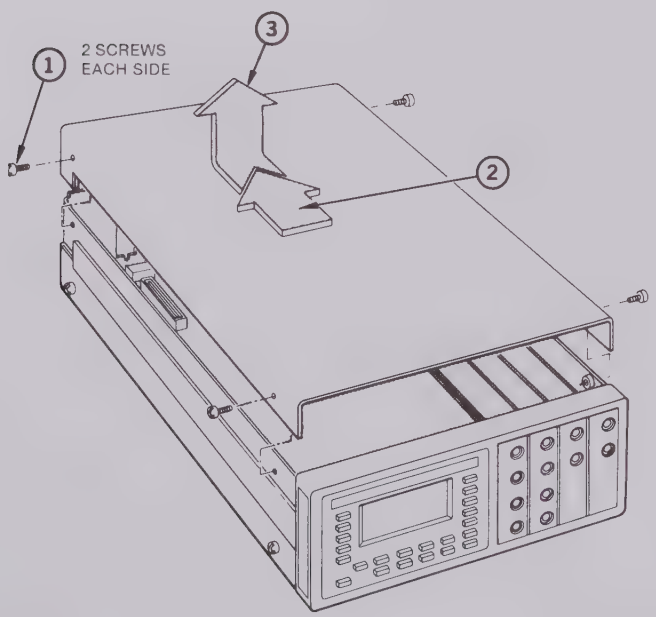


Figure 2-1. Top Cover Removal

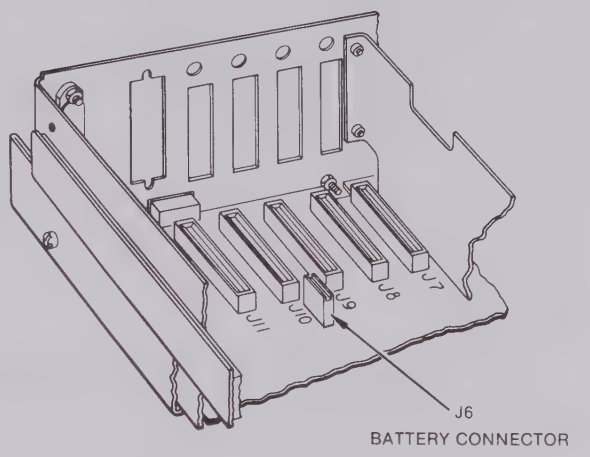


Figure 2-2. Battery Connection

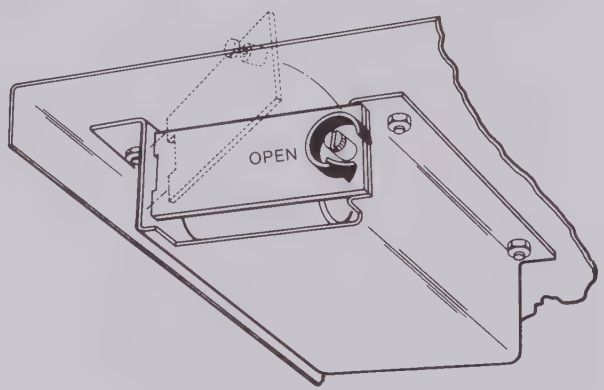


Figure 2-3. Battery Housing

Option 50-11 Rechargeable Battery does not need routine replacement. If Option 50-11 battery does need replacement, refer to section 5 of this manual.

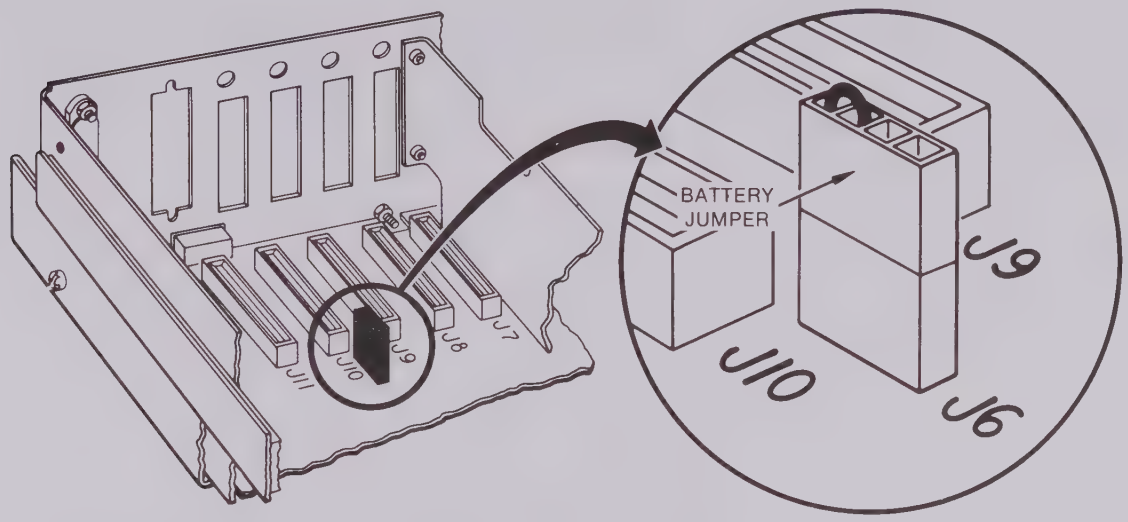


Figure 2-4. Battery Jumper

Battery Jumper

When Model 52 does not contain a battery option, a battery jumper is installed in the battery socket J6. Also, battery jumper must be used if the Model 52 came with a battery option and the batteries are not installed. Figure 2-4 shows battery jumper installation.

2.3.2 Fuses

Model 52 uses three types of fuses:

Rear panel power fuse.
Measurement module dc overload fuse.
Battery charger fuse.

Power Fuse

The power fuse, located on the rear panel, is a 1A, 3AG type fuse. Figure 2-5 illustrates the replacement of the power fuse.

DC Current Overload Fuse

The 320mA inputs to the Option 50-1 Measurement Modules are protected by 1A, 3AG type fuses. These fuses are accessible from the bottom of Model 52. Figure 2-6 illustrates replacement of one of the overload fuses.

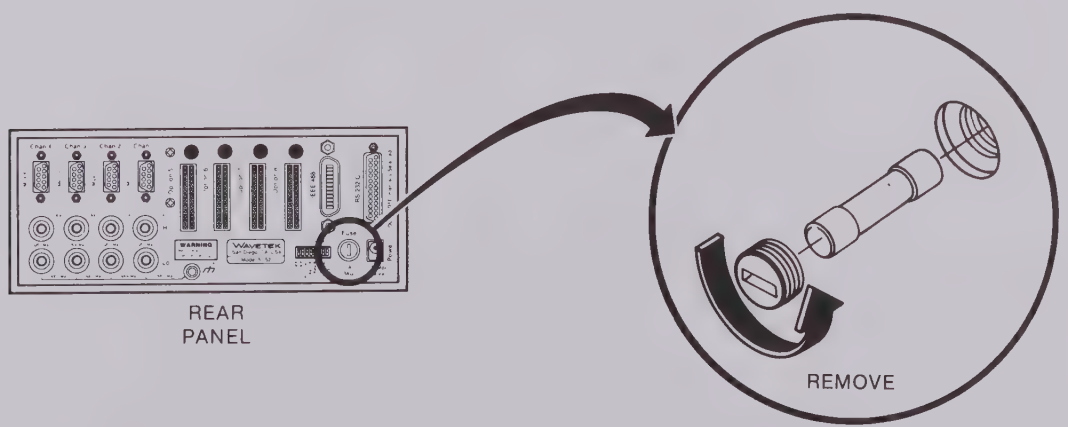


Figure 2-5. Power Fuse

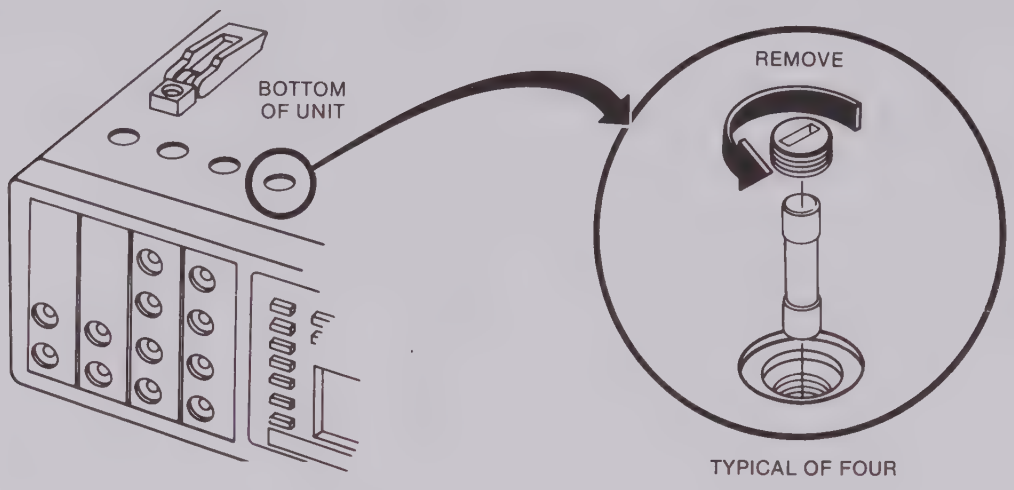


Figure 2-6. Overload Fuse

Battery Charger Fuse

The battery charger for the Option 50-11 Rechargeable Battery is protected by 1A, 3AG type fuse. Option 50-11 Rechargeable Battery is attached to the top cover. The following procedure describes battery charger fuse replacement.

1. Disconnect Model 52 from the power source.
2. Remove the top cover; see figure 2-1.
3. Disconnect battery cable from the circuit board; see figure 2-2.
4. Remove the battery charger fuse cover; see figure 2-7.
5. Replace the fuse with a 1A, 3AG type fuse.
6. Replace the battery charger fuse cover, connect the battery cable to the circuit board (figure 2-2), and replace the top cover (figure 2-1).

2.3.3 Inputs

Table 2-1 lists the input and output characteristics for the Option 50-1 and 50-2 Measurement Modules. The front and rear input connectors use dual banana connectors.

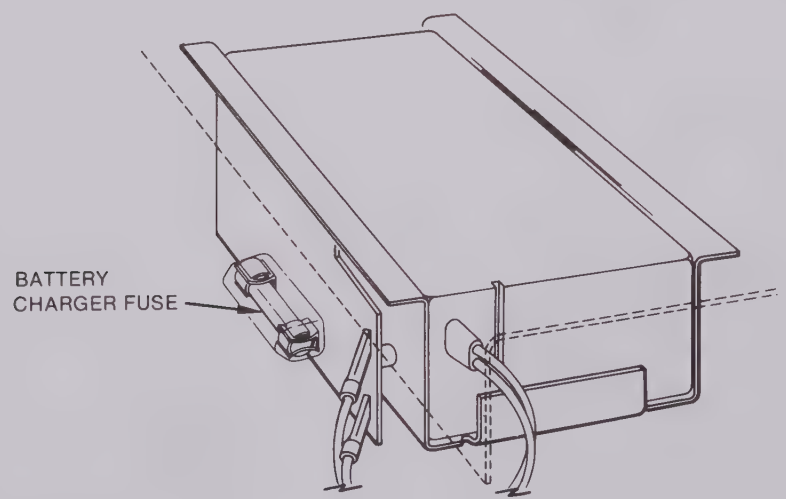


Figure 2-7. Battery Charger Fuse

Table 2-1. Input Characteristics of Modules 50-1 and 50-2

Input	Function	Specification
HI/LO V,Ω,Hz	Vdc, dBdc, Watts (Vdc ranges)	>1000MΩ/3.2V max., 10MΩ parallel with <50pF/320V max.
	Vac, Vac + dc, dB, Frequency, Period, Time Interval, Pulse Width, Volt-Amperes (Vac ranges)	1MΩ parallel with 50pF/320V max.
	Temperature	>1000MΩ/320mV max.
	Cold Junction Temperature	No external input
	Ohms, Continuity	**Output Current** / **Range** 1mA / 30Ω 1mA / 300Ω 1mA / 3kΩ 100μA / 30kΩ 10μA / 300kΩ 1μA / 3MΩ 0.1μA / 30MΩ Open circuit voltage, < + 10V at 1mA or less.
	High Megohms	0.1μA sourcing Rx in parallel with 10MΩ. Open circuit voltage < + 1.1V at 0.1μA or less.
	Diode Test	Output Currents: 1mA, 100μA, 10μA, 1μA, 100nA.
mA Input HI/LO	dc current, ac current, ac Volt-Amperes, dc Watts	**Maximum Burden Voltage** / **Current Range** 40mV / 30mA 400mV / 300mA
A Input LO/HI	dc current, ac current, ac Volt-Amperes, dc Watts	**Maximum Burden Voltage** / **Current Range** 150mV / 3A 500mV / 10A
Rear Panel Inputs	Vdc, dBdc, Watts (Vdc ranges)	>1000MΩ/3V max, 10MΩ ± parallel with <60pF/300V max.
	Vac, Vac + dc, dB, Frequency, Period, Time Interval, Pulse Width, Volt-Amperes (Vac ranges)	1MΩ parallel with 60pF/320V max.
	Temperature	>1000MΩ/300mV max.

2.3.4 RS-232-C

The RS-232-C I/O port pin connections and signal names are listed in table 2-2. The rear panel connector is a DB-25 connector and connects to a standard RS-232-C cable (interface type E). The data format is 8-bit, no parity, one stop bit.

Table 2-2. RS-232-C Data In/Out

Pin	Name	Direction (DCE Configuration	Direction (DTE Configuration
2	TXD (Transmit data)	In	Out
3	RXD (Receive data)	Out	In
4	RTS (Request to send)	No Connection	Out
5	CTS (Clear to send)	Out	In
6	DSR (Data set ready)	Out	In
7	SIG GRD (Signal ground)	—	—
8	RLSD (Receive line signal detect)	Out	In
20	DTR	In	Out

(Remaining pins are not connected.)

Baud Rate

The BAUD rate is selected by either the rear panel DIP switch or the RS-232-C main menu item. The rear panel DIP switch is described in paragraph 2.3.9.

DCE/DTE Configuration

Before connecting the Model 52 RS-232-C interface, the correct device configuration (DCE or DTE) must be determined and the internal ribbon cable connected to the DCE or DTE location (figure 2-8) on the Mother Board. The Model 52 is shipped set up for DCE operation.

To determine the correct device configuration, refer to the manual for the system controller/computer. The controller/computer must have a DB-25 RS-232-C connector.

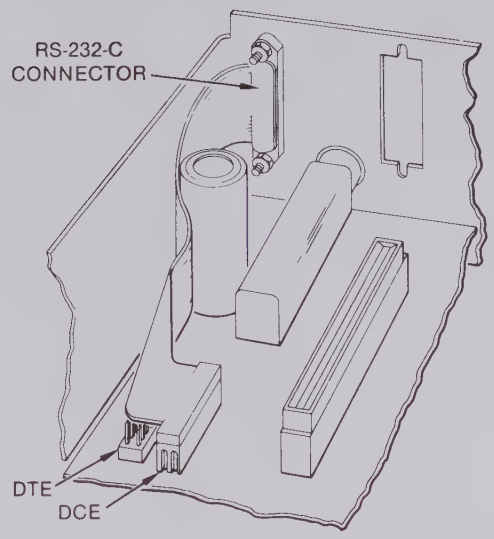
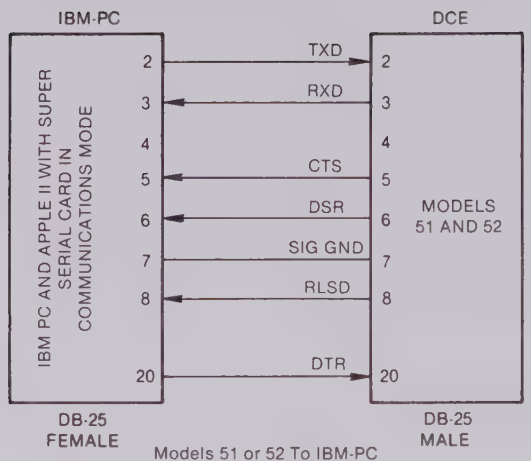
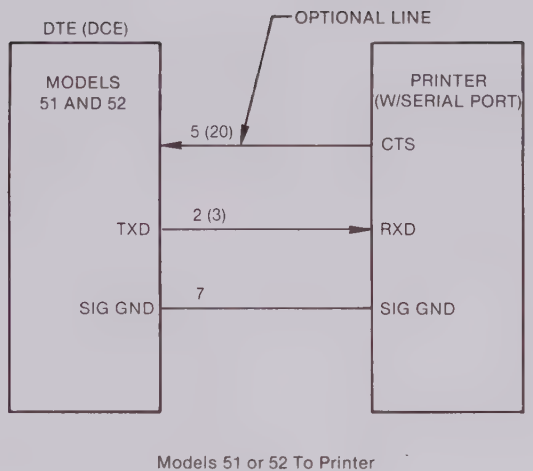


Figure 2-8. DCE/DTE Headers

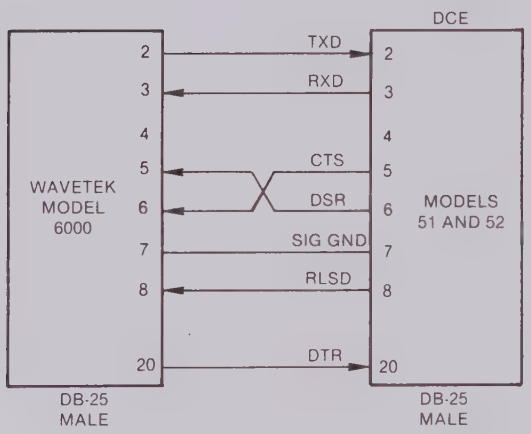
1. Is the controller/computer a DCE or DTE device? If this is not explicitly spelled out in the manual you will need to look at the connector's pins. If pin 2 is the data output, the controller/computer is a DTE (most computers). If pin 3 is data output, the controller/computer is a DCE (most MODEMS). Set the Model 52 opposite to the controller/computer (i.e. if the controller is DTE, set the Model 52 for DCE). To set the Model 52 remove the top cover (figure 2-1) and connect the cable to the appropriate header (figure 2-8).
2. In most cases a straight-through cable can be used to connect the Model 52 with the other device. Model 52 requires connection of pins 2, 3, 5, 7, and 20 for CTS/DTR handshaking or pins 2, 3, and 7 for data operation (no handshaking), but the other device may require more connections. Examples of typical cable assemblies are shown in figure 2-9. However, there are many interpretations for the RS-232-C standard. Either of the following procedures should be used to ensure that control and handshake signals are properly connected.



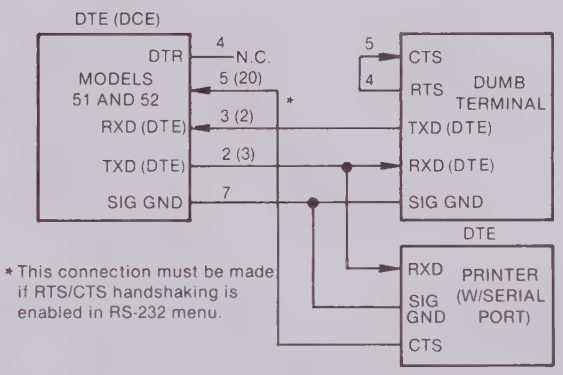
Models 51 or 52 To IBM-PC or Apple II



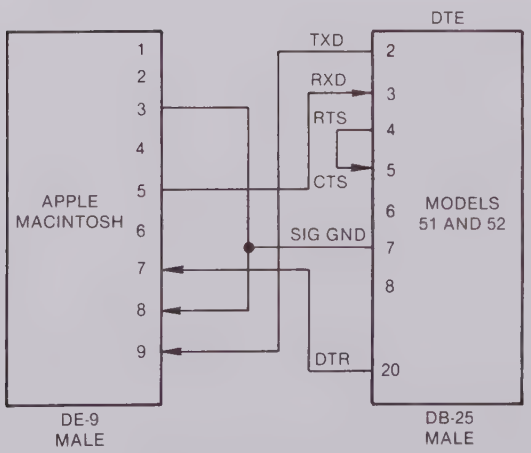
Models 51 or 52 To Printer



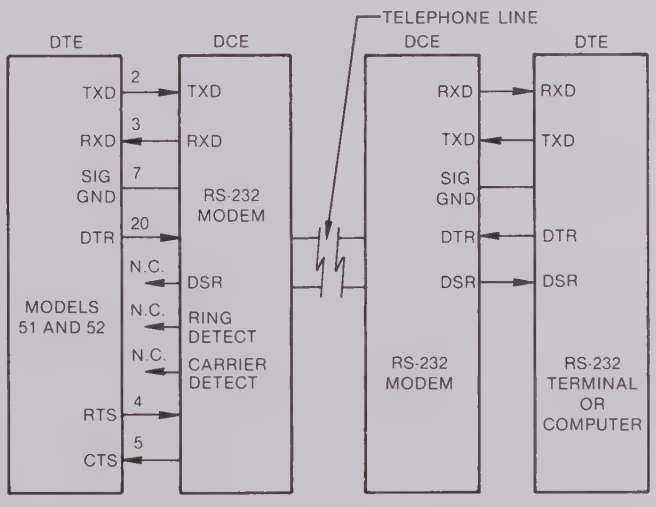
Models 51 or 52 To Wavetek Model 6000



Models 51 or 52 To Dumb Terminal With Tee For Printer



Models 51 or 52 To Apple Macintosch



Models 51 or 52 To Typical Modem Connection
(See Individual Modem Manual for Handshaking Lines Available)

Figure 2-9. Typical Serial Cables

2.3.5 IEEE-488 (GPIB)

Interface Connections

The IEEE-488 (GPIB—General Purpose Interface Bus) I/O port pin connections and signal names are listed in table 2-3. The rear panel connector is a Amphenol 57-10240 or equivalent connector and connects to a IEEE-488 cable (Available from Wavetek in 1 and 2 meter lengths).

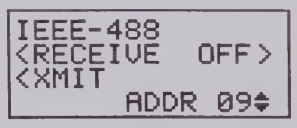
Table 2-3. IEEE-488 Data In/Out

Pin	Signal	
1	D101	True when low
2	D102	True when low
3	D103	True when low
4	D104	True when low
5	EOI	True when low
6	DAV	True when low
7	NRFD	True when high
8	NDAC	True when high
9	IFC	True when low
10	SRQ	True when low
11	ATN	True when low
12	Chassis ground	
13	D105	True when low
14	D106	True when low
15	D107	True when low
16	D108	True when low
17	REN	True when low
18	Signal ground	
19	Signal ground	
20	Signal ground	
21	Signal ground	
22	Signal ground	
23	Signal ground	
24	Signal ground	

IEEE-488 Address

Before using the IEEE-488 interface bus, verify the IEEE-488 address.

1. Turn on the Power.
2. Press **Func** key to call IEEE-488 in the main menu.
3. Select <IEEE-488.

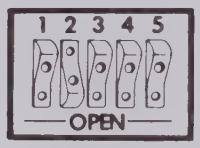


4. Verify the address (ADDR on the display).
5. Using the **▲▼** cursors keys to change the address.

At power up the Model 52 reverts to the default address set by the internal IEEE-488 address switch.

To change the IEEE-488 address using the internal address switch.

1. Disconnect the power.
2. Remove the top cover (figure 2-1).
3. Set the address using the IEEE-488 address switch located on the Option 50-13 card (figure 2-10). To verify the address, see "IEEE-488 Address" steps 1 through 4. The default (power on) address is always that of the internal IEEE-488 address switch.



Notes:

1. Switch 5 not used.
2. Shown setting = Binary 00010, device 2.

Figure 2-10. IEEE-488 Address Codes

Table 2-4. IEEE-488 Address Codes

Device	1	2	3	4	5
0	0	0	0	0	0
1	0	0	0	0	0
2	0	1	0	0	0
3	1	1	0	0	0
4	0	0	1	0	0
5	1	0	1	0	0
6	0	1	1	0	0
7	1	1	1	0	0
8	0	0	0	1	0
9	1	0	0	1	0
10	0	1	0	1	0
11	1	1	0	1	0
12	0	0	1	1	0
13	1	0	1	1	0
14	0	1	1	1	0
15	1	1	1	1	0
16	0	0	0	0	1
17	1	0	0	0	1
18	0	1	0	0	1
19	1	1	0	0	1
20	0	0	1	0	1
21	1	0	1	0	1
22	0	1	1	0	1
23	1	1	1	0	1
24	0	0	0	1	1
25	1	0	0	1	1
26	0	1	0	1	1
27	1	1	0	1	1
28	0	0	1	1	1
29	1	0	1	1	1
30	0	1	1	1	1

NOTE: Addresses 31 is not allowed.

The IEEE-488 can only be used when using an external power source (non internal batteries). To use the IEEE-488 interface with an external power source, the IEEE Power switch (see rear panel DIP Switch paragraph 2.3.9) must be turned on (down).

2.3.6 Grounding

The Chassis ground jack (⏚) is located on the rear panel. This banana jack may be connected to earth ground for electrostatic shielding, but this is not usually required.

2.3.7 Multiplexer

The multiplexer (Option 50-20) expands each measurement module channel by up to 64 inputs (subchannels). A single multiplexer handles up to 16 single ended inputs (8 differential inputs). Several multiplexers can be daisy chained together for up to 64 inputs. Section 4 describes operating the multiplexer (paragraphs 4.5.1.1 and 4.6.1). When measuring temperature with a multiplexer, every set of subchannel numbers for each multiplexer module must include at least one cold-junction temperature measurement.

Setting Up the Multiplexer

To begin setting up the 50-20 multiplexer, remove the four screws from the bottom of the multiplexer to access the internal switch and termnal strips. Figure 2-11 shows the multiplexer. Figure 2-12 shows a simplified diagram of the 8/16 channel multiplexer.

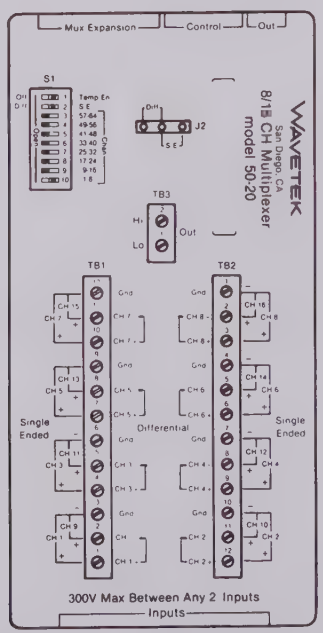
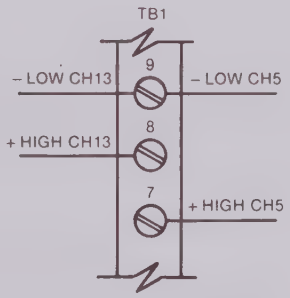


Figure 2-11. 50-20 Multiplexer

Single Ended Setup

Single-ended inputs should be used when the signal inputs share a common ground and have high signal level. To measure single-ended inputs using the multiplexer, set up the multiplexer module (figure 2-11) as follows,

1. Set switch S1 for single-ended inputs by sliding position 2 switch to "S.E" (single ended).
2. Set patch block J2 for single-ended inputs by connecting the jumper in J6 for "S.E".
3. Connect inputs to terminal strips TB1 and TB2. Single ended inputs (figure 2-10) are shown around the outside of the terminal strips. The following shows single ended input connections for Channels 5 and 13. Single ended inputs share ground as a common point.



4. Select the subchannels as follows. For single ended inputs, select any two groups of eight subchannels. The closed position (opposite side of "Open") selects the subchannel group. Switch S1 in figure 2-10 shows subchannels 1 – 8 as being selected.

Differential Setup

Differential inputs should be used when measuring isolated signals and when the noise level is higher than the signal level. To measure differential inputs using the multiplexer, set up the multiplexer module (figure 2-11) as follows,

1. Set switch S1 for differential inputs by sliding position 2 switch to "Diff" (Differential).
2. Set patch block J2 for differential inputs by connecting the jumper in J6 for "Dif".
3. Connect the inputs to terminal strips TB1 and TB2. Differential inputs (figure 2-11) are shown around the inside of the terminal strips. The following shows differential input connections for Channel 5.
4. Select the subchannels. For differential inputs, select any single group of eight subchannels. The closed position (opposite side of "Open") selects the subchannel group. Switch S1 in figure 2-11 shows subchannels 1 – 8 as being selected. Grounds should not be connected when making differential measurements.

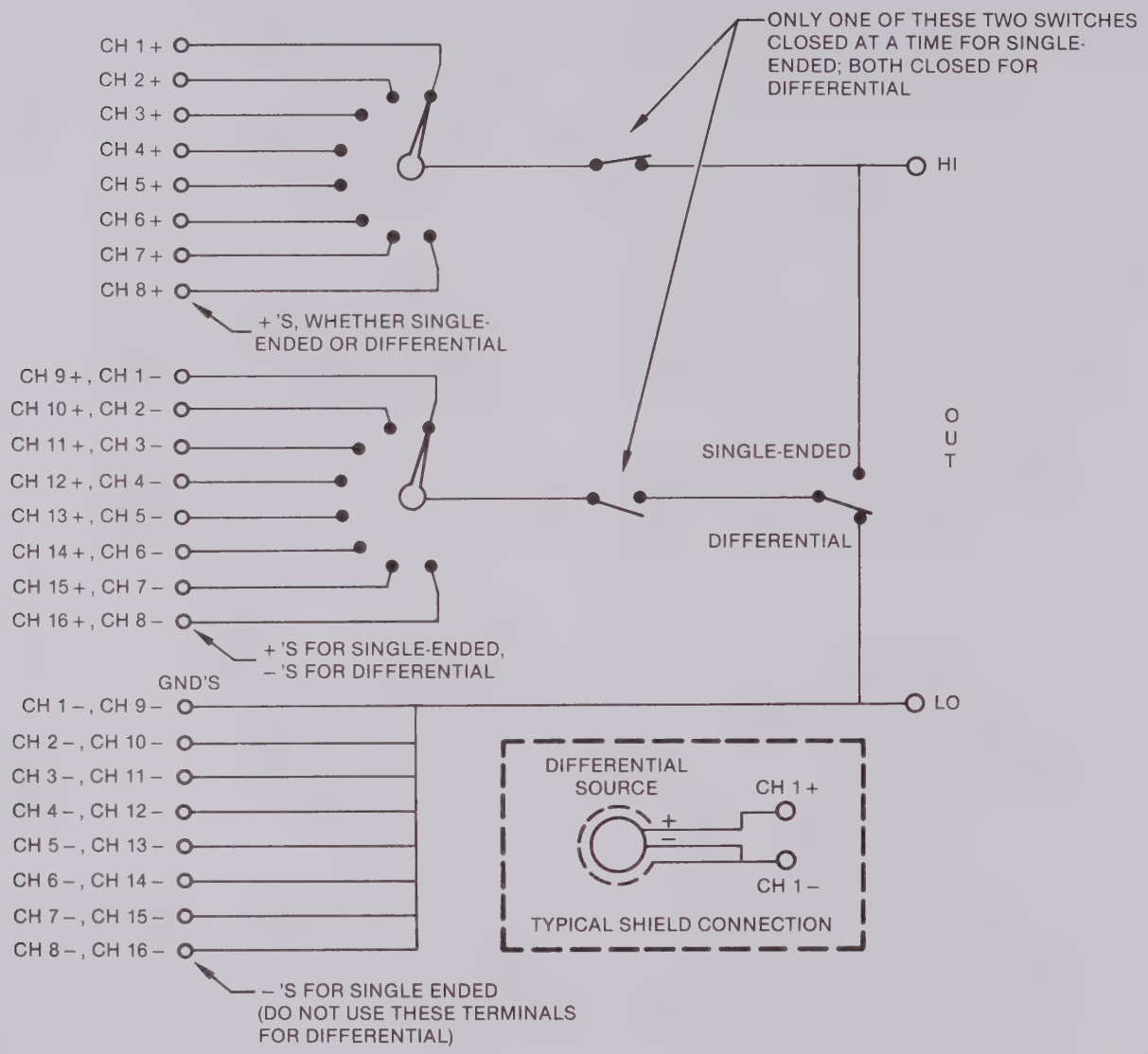
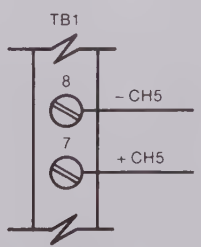

ONLY ONE OF THESE TWO SWITCHES CLOSED AT A TIME FOR SINGLE-ENDED; BOTH CLOSED FOR DIFFERENTIAL
CH 1 +
CH 2 +
CH 3 +
CH 4 +
CH 5 +
CH 6 +
CH 7 +
CH 8 +
HI
+ 'S, WHETHER SINGLE-ENDED OR DIFFERENTIAL
CH 9 +, CH 1 –
CH 10 +, CH 2 –
CH 11 +, CH 3 –
CH 12 +, CH 4 –
CH 13 +, CH 5 –
CH 14 +, CH 6 –
CH 15 +, CH 7 –
CH 16 +, CH 8 –
SINGLE-ENDED
DIFFERENTIAL
OUT
+ 'S FOR SINGLE-ENDED, – 'S FOR DIFFERENTIAL
GND'S
CH 1 –, CH 9 –
CH 2 –, CH 10 –
CH 3 –, CH 11 –
CH 4 –, CH 12 –
CH 5 –, CH 13 –
CH 6 –, CH 14 –
CH 7 –, CH 15 –
CH 8 –, CH 16 –
LO
DIFFERENTIAL SOURCE
CH 1 +
+
–
CH 1 –
TYPICAL SHIELD CONNECTION
– 'S FOR SINGLE ENDED (DO NOT USE THESE TERMINALS FOR DIFFERENTIAL)

Figure 2-12. 8/16 Channel Multiplexer Simplified Switching Diagram

Connecting the Multiplexer to the Model 52

To connect the multiplexer to Model 52, connect the multiplexer control cable to the Model 52 "Mux" connector. The multiplexer "Out" cable connects to the Model 52 rear panel Hi/Lo inputs. Both cables must connect to the same channel. Figure 2-13 shows multiplexer/Model 52 interconnection.



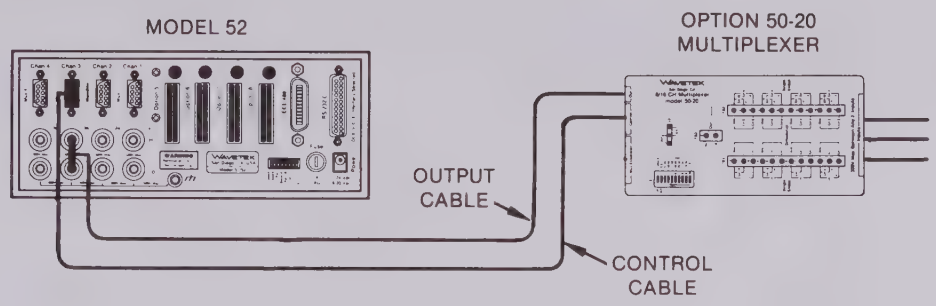


Figure 2-13. Multiplexer/Model 52 Interconnection

Daisy Chaining the Multiplexer

Up to four single ended or eight differential connected multiplexers can be connected together for up to 64 sub-channels per channel. To interconnect the multiplexers (figure 2-14),

1. Connect all the multiplexer output cables in parallel to the Model 52 rear panel Hi/Lo connector.
2. Connect the multiplexer "Control" cable to the Model 52 rear panel "Mux" connector.
3. Connect the next multiplexer "Control" cable to the first multiplexer's "Mux Expansion" connector. Continue connecting the multiplexers together until all are connected.

Another method of interconnecting the "Output" cables is to daisy chain the output cables (figure 2-15). To install the output cable,

1. Remove the multiplex cover (see Setting Up the Multiplexer).
2. Replace the "Output" cable connected to TB3 with dual twisted pair cables.
3. Connect "Output" cable from the closest multiplexer to Model 52 rear panel Hi/Lo connector.

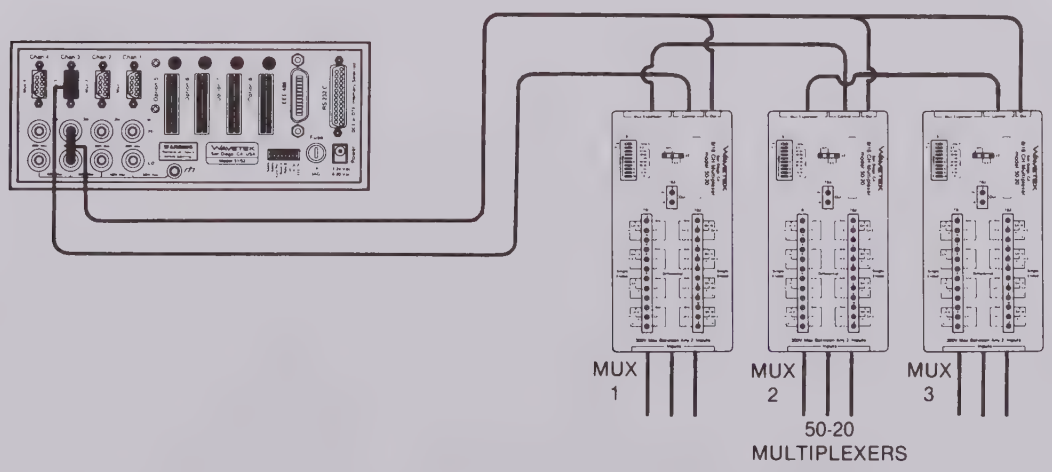


Figure 2-14. Multiplexer Interconnection

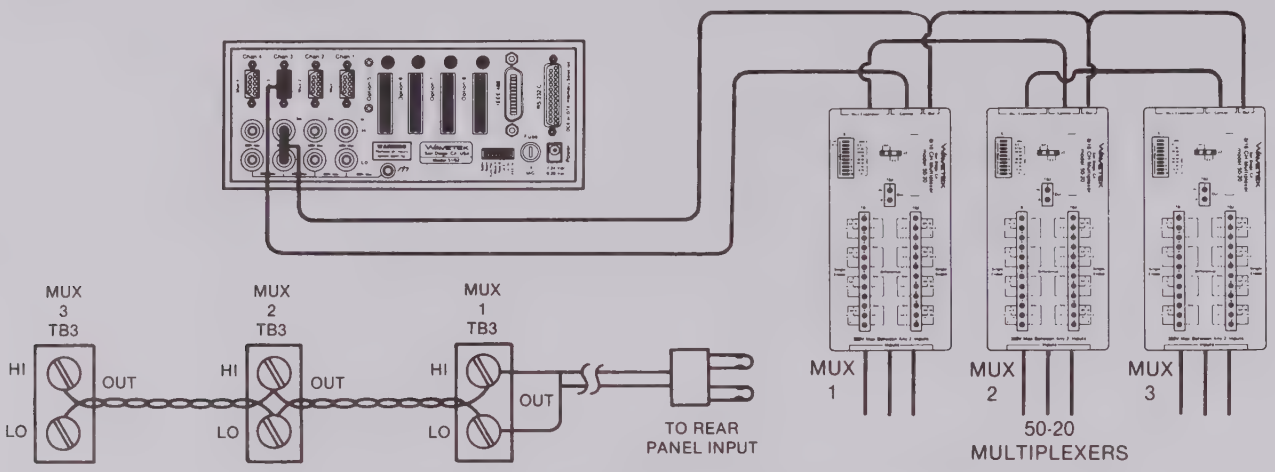


Figure 2-15. Daisy-Chained Output Cables

2.3.8 Digital I/O Connector

The Option 50-14 Digital I/O rear panel connections are shown in figure 2-16. The Digital I/O connector is Amp 746094-6 connector or equivalent. Accessory 50-32 provides terminal strip connections for the Digital I/O connector.

Digital I/O and Analog Output Breakout Module

Accessory 50-32 Digital I/O and Analog Output Breakout Module (figure 2-17) provides convenient terminal strip connections for Digital I/O channels.

Setting Up the Breakout Module — To set up the Breakout Module,

1. Remove the four screws from the module bottom to gain access to the module's terminal strips.
2. Connect the wires to the appropriate terminals.
3. Replace the cover.

Connecting the Breakout Module to the Model 52 — To connect Breakout Module to Model 52 (figure 2-18), connect the Breakout Module ribbon cable to the Model 52 Digital I/O connector.

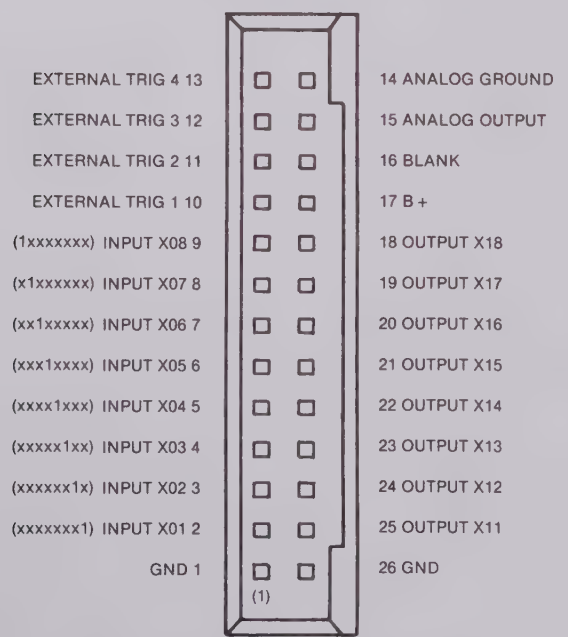


Figure 2-16. Digital I/O Connector

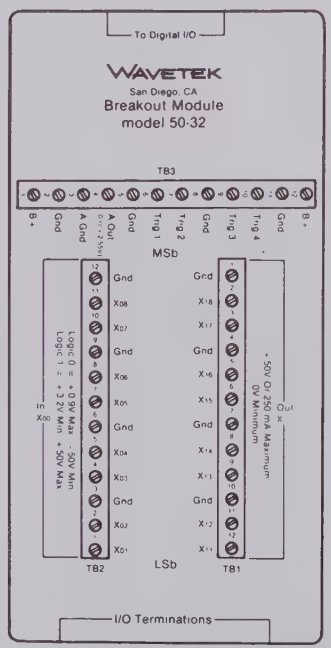


Figure 2-17. Digital I/O Breakout Module

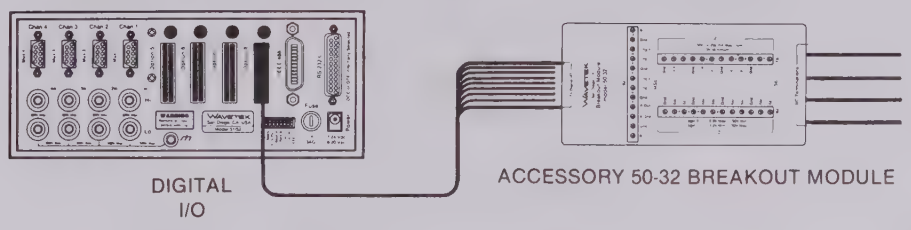


Figure 2-18. Breakout Module/Model 52 Interconnection

2.3.9 Rear Panel DIP Switch

Figure 2-19 shows the rear panel DIP switch, and the following text describes each switch function.

1 Spare switch is undefined.

2 Pwr En switch enables or disables the front panel **Power** switch. In the closed position (switch down), this switch disables the **Power** switch which keeps the power from accidently being turned on during shipment. The open position (switch up) the **Power** switch is enabled.

3 Auto Pwr switch enables or disables automatic power. When enabled (switch down), any character sent over the RS-232-C turns power on. After receiving the character, Model 52 waits approximatly 100 ms before any RS-232-C data is accepted. When the switch is down, Auto Pwr is disabled.

4 & 5 RS-232-C Baud rate switches select the default baud rate which Model 52 reads at power on.

Baud A	Baud B	Baud Rate
Up	Up	300
Down	Up	1200
Up	Down	9600
Down	Down	76.8K

The Baud rate also can be set from the "RS-232-C" menu.

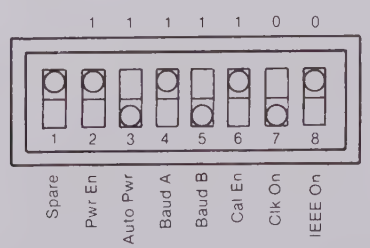


Figure 2-19. Rear Panel DIP Switch

6 Cal En switch enables or disables calibration. Calibration must be enabled (switch up) before calibration. Calibration must be disabled (switch down) to prevent calibration.

7 Clk On switch enables or disables the internal real time clock. If the unit is unused for a long period (>1 month) without external power or internal batteries, the clock should be disabled (switch up). Turning off the clock power increases the life of the lithium Cal RAM battery.

8 IEEE On switch enables or disables power for the IEEE-488 option. When enabled (switch down) and using an external power source, power is applied to the IEEE-488 board. If operating from external batteries, disabling the IEEE power conserves battery power.

2.4 OPERATION VERIFICATION

The operation verification procedure (table 3-1) gives you a chance to verify the hardware and software of the Model 52 and to briefly familiarize yourself with Model 52 operation. The first 11 steps check the hardware and software operation. Steps 12, 13, and 14 demonstrate how to operate the Model 52.

Before you begin there are two terms used in the table that must be explained.

Press means press "that" front panel key. For example, "Press **Range** " means press the key labled Range.

Select means select that menu item. Each menu item has arrows (< or >) pointing to the key that selects that item. Press that key to select the item. For example, "Select DMM" means to select the DMM mode you press the key the <DMM arrow points to.

Table 2-5. Operation Verification

Step	Action	Display	Comments
1	Press **Power**	<DMM <CHANNEL LIST <PROGRAM <RECALL DATA	Turning the Power on brings up the main menu. This verifies the Model 52 works correctly.
2.	Press **Disp**	<DISPLAY MODE <MONITOR MODE <KEYBOARD LOCK <TIME/DATE	
3.	Press **Mods**	<MATH <ALARMS <TRACKING <UNIT STATUS	
4.	Press **Range**	<UNIT STATUS <MEMORY STATUS <CONFIGURATION <DATA ROUTING	
5.	Press **Func**	<DATA ROUTING <TRANSMIT/MEM <IEEE-488 <RS-232-C	
6.	Press **Chan**	<TEST.L R> <8CH TEMP.P R> <PS EFFIC.L R> <4CH DMM.L R>	The most recently entered channel list or program appears at the bottom of the display.
7.	Press **Range**	<UNIT STATUS <MEMORY STATUS <CONFIGURATION <DATA ROUTING	Verify that "Pwr En" (paragraph 2.3.9) is on (Up).
8.	Select CONFIGURATION	(example shown) MODEL52 V4.22C CH1: 50-1 DMM CH2: 50-1 DMM CH3: 50-2 V+T CH4: OP5: 50-14 I/O OP6: 50-14 I/O OP7: OP8: 50-13GPIB OP9: 50-12-128 BATT 50-11 RCH	Selecting CONFIGURATION verifies the the measurement modules and rear panel cards operate correctly. Software version 4.23G. CH1: Option 50-1. CH2: Option 50-2. CH3: Option 50-2. CH4: No module. OP5: Digital I/O card. OP6: Digital I/O card. OP7: No card. OP8: Option 50-13. (GPIB power must be on; see paragraph 2.3.9). OP9: Option 50-12 Memory expansion. Option 50-11 Rechargeable battery.

Table 2-5. Operation Verification (Continued)

Step	Action	Display	Comments
9.	Press **Menu**	<UNIT STATUS <MEMORY STATUS <CONFIGURATION <DATA ROUTING	
10.	Press **Disp**	<DISPLAY MODE <MONITOR MODE <KEYBOARD LOCK <TIME/DATE	
11.	Press **TIME/DATE**	22:38:45 ◀TIME DATE> <SET	Verify the time and date of the Model 52's real time clock is correct.
	Select **DATE**	01-27-87 <TIME DATE▶ <SET	
12.	Perform example 3-1 in section 3 to get a feel of operating the Model 52 as a DMM — (Digital Multimeter).		
13.	Perform example 3-2 in section 3 to get a feel of operating the Model 52 as a (channel list) Multichannel DMM.		
14.	Perform example 3-3 in section 3 to get a feel of setting up a program.		

SECTION 3
OVERVIEW

3.1 INTRODUCTION

This section gives an overview of the Models 51 and 52 Data Multimeters.

This section is organized as follows:

- The physical overview describes front and rear panel "controls" and connectors.
- The operational overview describes the concepts that are needed to operate the Models 51 and 52.
- The quick reference guide provides a summary of Model 51 and 52 operation.

3.2 MODEL 52 FRONT PANEL

The following paragraphs describe the elements of a typical Manual 52 front (figure 3-1). The numbered items in figure 3-1 are keyed to the following descriptions.

1 **Display** — This display, a 32 by 84 dot matrix Liquid Crystal graphics Display (LCD), shows menus and readings which include channel number, function, and range. Readings may be displayed as large characters (single channel DMM display), four lines (multiple channel DMM display), and bar graphs (mixed with readings). Paragraphs 3.2.1, 3.2.2, and 3.2.3 illustrate and explain several typical displays.

2 **Numeric Keys** — These keys enter numeric values, make menu selections, control the keystroke beeper, and vary the display's viewing angle. When menus are being displayed, keys 1 through 4 and 6 through 9 select menu items. The selection key for a given menu item is "pointed to" by the screen pointers <, >.

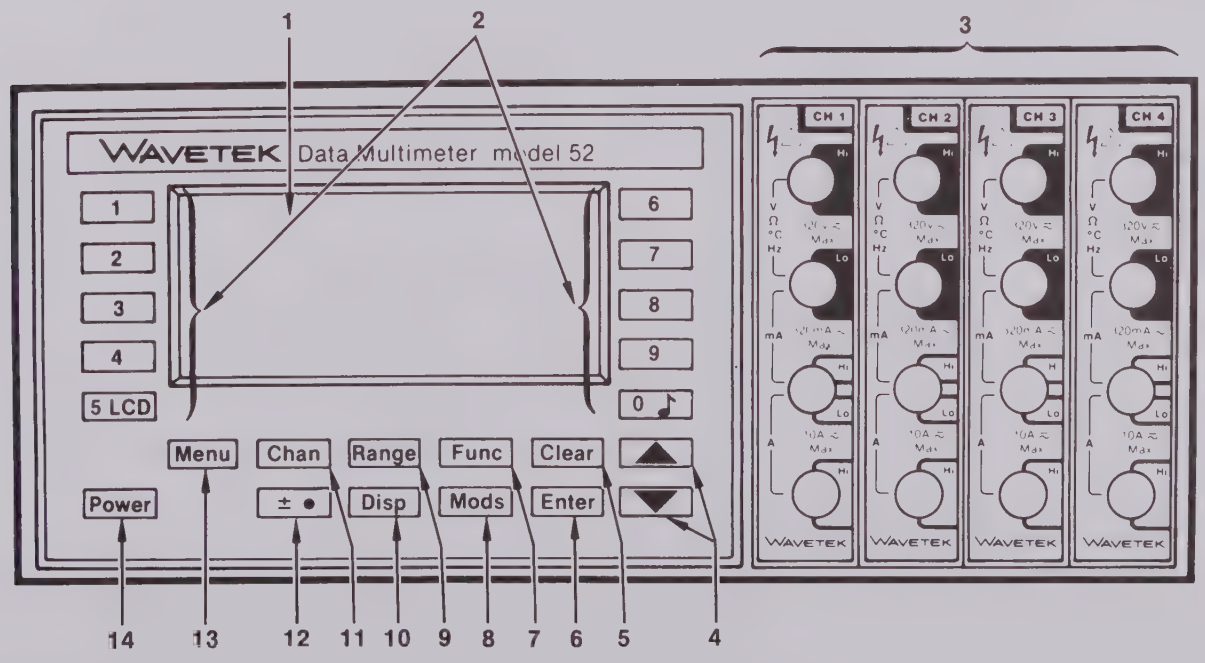


Figure 3-1. Model 52 Front Panel

Keys 5LCD and 0 ♪ perform other functions when not entering numeric values. Key 5LCD varies the "viewing angle" of the screen through eight "viewing angle" steps. Key 0 ♪ turns on or off the keystroke beeper.

3 **CH1 through CH4 Modules** — These modules are a mix of up to four of two types of measurement modules (Options 50-1 and 50-2) that can be installed in the Model 52.

4 ▲ ▼ **Cursor Keys** — These keys are used to scroll through menus and multiple channel DMM readings. If the Display Mode (see paragrph 4.3.1) is set to HOLD, the cursor keys are used to step to the next reading.

5 Clear — This key deletes numeric and character entries by back spacing through unwanted entries. Clear also aborts a menu item that has been selected but not "entered" (see item F, Enter); the menu returns to the last entered item.

6 Enter — This key accepts a new entry.

7 Func — This key calls a menu that lists available functions (function menu). In the function menu, the Func key calls another group of function menus. In the main menu, the Func key calls a group of items that can be used to set up data handling and communications.

8 Mods — This key calls a menu which allows selection of how the channel takes and responds to a reading (function modifier). In the main menu, the Mods key calls a group of items that set up function modifier items (see paragraph 4.5.5).

9 Range — This key calls a menu which lists available ranges (range menu) for a selected function. In some range menus, the Range key calls a second group of ranges. In the main menu, the Range key calls items that list unit status and set up data routing.

10 Disp — This key calls a menu which allows selection of ways to display the reading (display modifier). In the main menu, Disp key calls the items which control the instrument.

11 Chan — This key allows entry of a channel and subchannel number.

In the main menu, Chan key, brings up a list of channel lists (lists of user assigned, user named multiple channel DMM setups) and measurement programs (channel lists with user assigned names with beginning and ending conditions). The first channel list or program entered appears at the top of the list. This is the equivalent to the DIR remote comand (paragraph 5.7.11).

12 ±• — This key changes the sign of the numeric entry. In the main menu, ±• key performs the same function as item 11, Chan except the oldest channel list or program appears at the top of the display. This is equivalent to the DIR remote command (paragraph 5.7.11).

13 Menu — This key aborts any new selection that has not been "entered" and returns to the last higher-level menu or the main menu. In the main menu, the Menu key calls items that returns to the "top" of the main menu.

14 Power — This key instructs the microprocessor to turn Model 52 power on or off. Power is shut off by the microprocessor only after completion of its housekeeping chores. Power also can be automatically be shut off between groups of measurements in a program (data logger); see paragraph 4.7.3.1, Monitor Mode.

3.2.1 Single Channel DMM Display

Figure 3-2 shows a typical single channel DMM display. The elements are described in the following paragraphs.

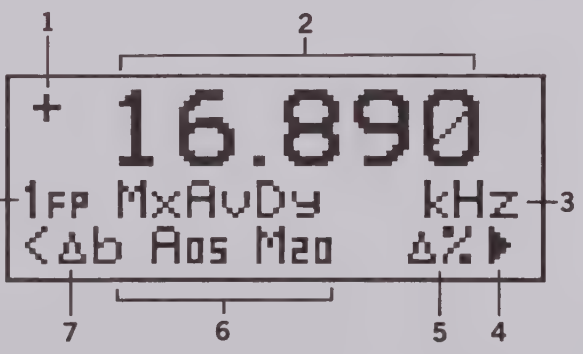
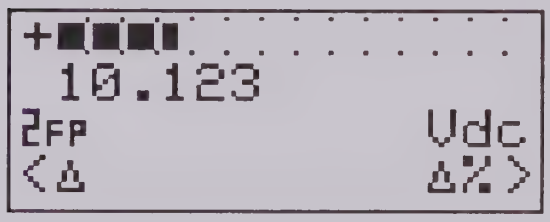


Figure 3-2. Single Channel DMM Display

1 + — This position displays the polarity of the reading. A plus (+) or blank indicates a positive polarity reading. A minus (−) indicates a negative polarity reading. A percent (%) indicates the reading is a percentage (see item 5).

2 **16.890** — This position displays the reading. If the reading exceeds six digits the display changes from the large number display to a small number display. If a bar graph is chosen for a DMM type display (see below) the top line displays the bar graph (see paragrph 4.5.4, Bar Graphs) and the second line displays the reading.



3 **kHz** — This position displays the unit of measure. Black background indicates alarm conditions are "true" (see paragraph 4.5.5.1, Alarms). Pressing the key to the right of this item selects a multiple channel DMM display (providing a multiple channel DMM is running) and pressing the key again returns to the single channel DMM display.

4 ► — This character points to the key which can select the item. The solid pointer (►) indicates a selected item (Δ% has been selected).

5 **Δ% (delta percent)** — When the key to the right of this item is pressed, the reading at that time becomes the base value. Subsequent measurements are displayed as the percent of change relative to the base value. A bΔ indicates the reading is the percent of change relative to a user-entered base value. See paragraph 4.5.4.1, Delta.

6 **Mx, Av, Dy, A05, and M20** — These items identify how the channel reading is displayed (see paragraph 4.5.4, Display Modifier) and how a channel reading is taken or how the unit responds to the channel reading (see paragraph 4.5.5, Function Modifier).

Mx — Maximum reading is being displayed.
Mn — Minimum reading is being displayed.
Av — Averaged reading is being displayed.
Dy — Measurement is delayed before being taken and displayed.
M20 — A measurement scaled by math channel 20 is being displayed.
A05 — This measurement is being monitored by alarm number 5.

7 **Δ (delta)** — When the key to the left of this item is pressed, the reading at that time becomes the base value. Subsequent measurement are displayed as the change in reading relative to the base value. A Δb% indicates the reading is the change in reading relative to a user-entered base value. See paragraph 4.5.4.1, Delta.

8 1_{FP} — This position displays the channel and subchannel number of the displayed reading.
FP indicates the measurement is taken using front panel measurement module connections.
00 indicates the measurement is taken using rear panel measurement module connections.
01 through 64 indicates the measurement is taken using multiplexer connections.

3.2.2 Multiple Channel DMM Display

Figure 3-3 shows a typical multiple channel DMM display. The elements are described in the following paragraphs.

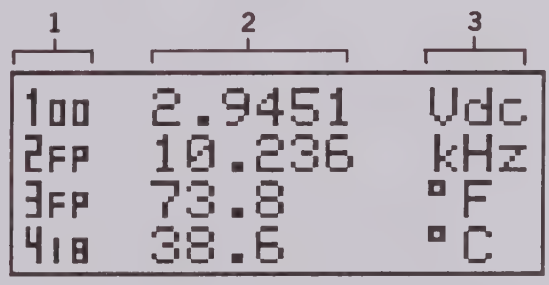


Figure 3-3. Multiple Channel DMM Display

1 1_{00} — This column displays the channel and subchannel numbers of the displayed readings.
00 indicates the measurement is taken using rear panel measurement module connections.
FP indicates the measurement is taken using front panel measurement module connections.
01 through 64 indicates the measurement is taken using multiplexer connections.

2 **2.9451** — This column displays the readings.

3 **Vdc** — This column displays units of measure. Pressing the key to the right of an item switches to a single channel DMM display of the item. Press the key next to the units of measure (8) to return to the multiple channel DMM display. Black background indicates the alarm conditions are true (see paragraph 4.5.5.1, Alarms).

3.2.3 Menu Items Display

Figure 3-4 shows a typical menu display. The elements are described in the following paragraphs.

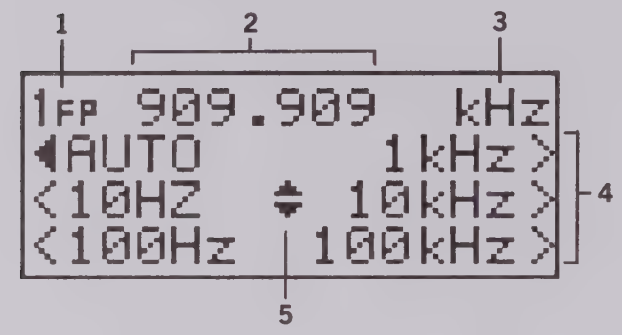


Figure 3-4. Menu Display

1 1_{FP} — This position displays the channel and sub-channel number of the displayed reading.
- FP indicates the measurement is taken using front panel measurement module connections.
- 00 indicates the measurement is taken using rear panel measurement module connections.
- 01 through 64 indicates the measurement is taken using multiplexer connections.

2 **909.909** — This position displays the reading.

3 **kHz** — This position displays unit of measure. Black background indicates alarm conditions are true (see paragraph 4.5.5.1, Alarms).

4 **1kHz►** — A menu item can be selected by pressing the key the arrow (►) points to. In this case, it would be the 1kHz range; notice that there are six ranges displayed and that the auto-range has been selected; the solid pointer (◄) indicates the selected range.

5 **▲▼** — The double-headed arrow indicates that the menu continues to another screen. Use either the **▲▼** cursor keys or the **Range** key in range menus or **Func** key in function menus to advance to the next screen. In this case, more ranges will be displayed.

3.3 MODEL 51 FRONT PANEL

The following paragraphs describe the elements of a typical Model 51 front panel (figure 3-5). The numbered items in figure 3-5 are keyed to the following descriptions.

1 **CH1 through CH4 Modules** — These modules are a mix of up to four of two types of measurement modules (Options 50-1 and 50-2) that can be installed in the Model 51.

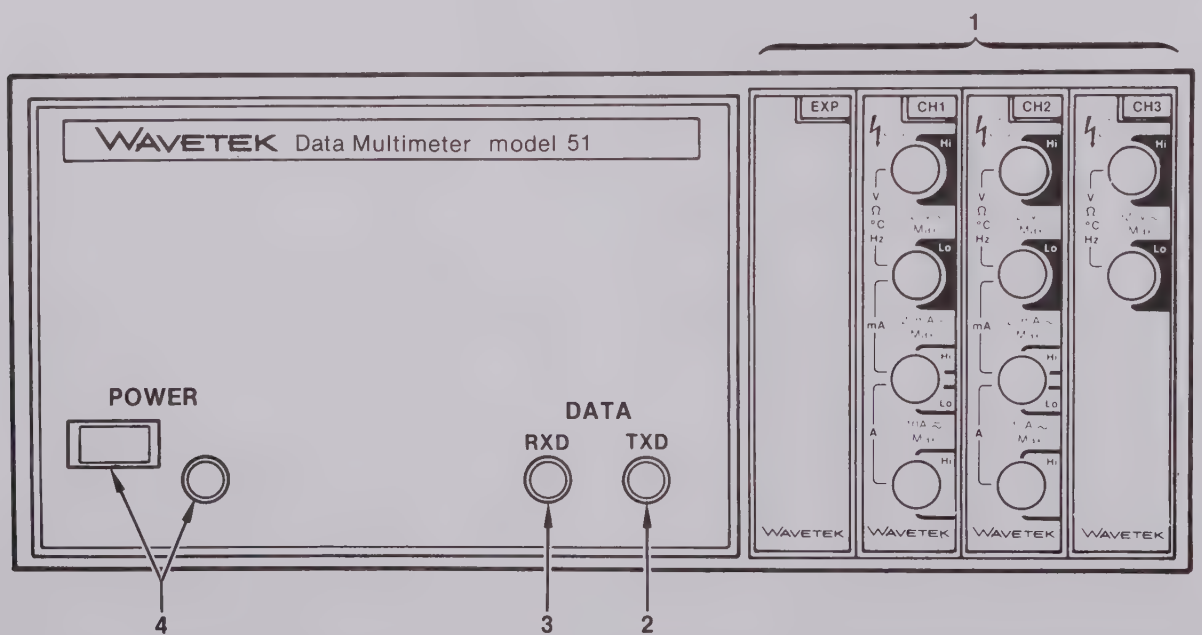


Figure 3-5. Model 51 Front Panel

2 **DATA TXD** — This indicator lamp lights when the Model 51 is transmitting data.

3 **DATA RXD** — This indicator lamp lights when the Model 51 is receiving data.

4 **POWER Switch and Indicator** — The power switch turns the Model 51 on and off. When the indicator is lit, the power is on. If the indicator is not lit, the power is off. A flashing POWER indicator means the rechargeable battery (Option 50-11) is low and needs recharging.

3.4 MODELS 51 AND 52 REAR PANEL

The following paragraphs describe the elements of a typical Models 51 and 52 rear panel. The numbered items in figure 3-6 are keyed to the following descriptions.

1 **Option (Positions) 5 through 8** — These option positions allow the installation of internal circuit cards (Digital I/O Channel or Memory Expansion RAM Cards) that can be installed in various combinations.

Digital I/O Channel Card — This card (Option 50-14) allows 8 bits of digital input (read), 8 bits of digital output (write), and analog output. The digital and anlog outputs can be used for control applications. This card also allows the "stop" trigger input for time interval measurements and external triggers for program start and stop. Model 51 and 52 can contain a maximum of four Digital I/O cards.

Memory Expansion RAM Card — These memory cards expand the storage capacity of the Model 52. There are two memory expansion options:

128K memory expansion (Option 50-12-128)
256K memory expansion (Option 50-12-256)

2 **IEEE-488 (GPIB) Port** — This position allows an option connector and internal circuit card (Option 50-13), which support the General Purpose Instrument Bus (IEEE-488 specifications) for instrument control and monitoring. The IEEE card allows talk and listen communication using IEEE-488-1978 conventions. IEEE-488 connector (attached to the IEEE-488 circuit board by ribbon cable) can only be installed as shown in figure 3-6; however, the circuit card can be installed in the mother board connector (J11) directly behind the IEEE-488 connector or in the position (J10) directly behind the Option (Postion) 8 slot. Also, a RAM card (Option 50-12) can be placed in connector J11.

3 **RS-232-C Serial Port** — This port is the Model 52 standard remote interface with selectable baud rate using the rear panel switch or by menu. The RS-232-C interface is configured by selecting either internal DCE or DTE connector; see paragraph 2.3.4, DCE/DTE Configuration.

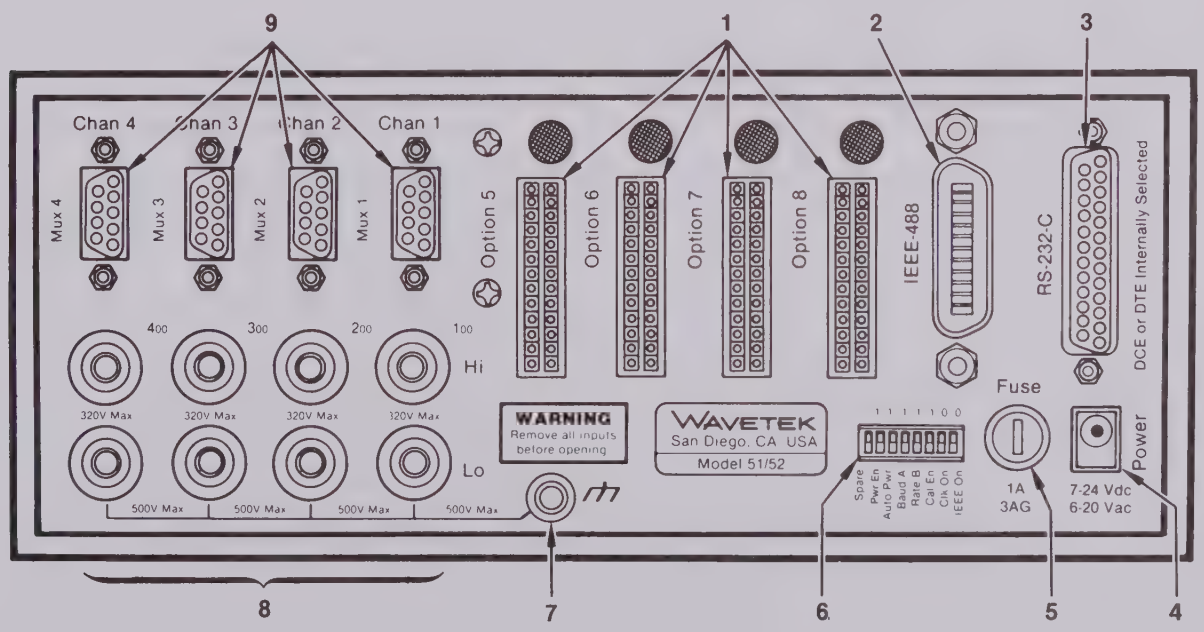
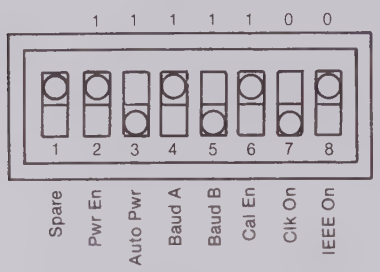


Figure 3-6. Model 52 Rear Panel

4 **Power** — This is the power input for Model 52. The power source is a line transformer (furnished), 7 to 24 Vdc isolated source, or 6 to 20 Vac isolated source; see paragraph 2.3.1.

5 **Fuse** — Input power fuse is a 1A, 3AG type fuse.

6 **Switches**



Switch S1

Spare — Switch is undefined.

Pwr En — This switch disables or enables the front panel **Power** switch. In the closed position (switch down), this switch disables the front panel **Power** switch which keeps the power from accidently being turned on during shipment. In the open position (switch up), this swich enables the front panel **Power** switch.

Auto Pwr — This switch enables or disables automatic power. When enabled (switch up), any character sent over the RS-232-C turns power on. After receiving the character, Model 52 waits approximatly 100 ms before any RS-232-C data is accepted. When the switch disabled (switch down), Auto Pwr is disabled.

Baud A and Baud B — These switches select the default RS-232-C baud rate, which Model 52 reads at power on. The baud rate also can be set at the front panel from the "RS-232-C" menu, but resets to the rate selected by the switches at power-on.

Baud A	Baud B	Baud Rate
Up	Up	300
Down	Up	1200
Up	Down	9600
Down	Down	76.8K

Cal En — This switch enables or disables calibration. Calibration must be enabled (switch up) before calibrating the Model 52. Calibration must be disabled (switch down) to protect from accidental calibration.

Clk On — This switch disables or enables the internal real time clock. If the unit is unused for a long period (typically >1 month) without external power or the option 50-10 and 50-11 internal batteries, the clock should be disabled (switch up). Turning off the clock power increases the life of the lithium RAM battery. Sliding the switch down enables the internal real time clock.

IEEE On — This switch enables or disables power for the IEEE-488 option. When enabled (switch down), and using an external power source, power is applied to the IEEE-488 board.

7 **Grounding Jack** — This jack is used to connect the Model 52 to earth ground. Maximum allowable differential voltage between the grounding jack and a Lo connector is 500V.

8 **Hi and Lo Signal Inputs** — These are the rear panel connectors to the measurement modules. The connectors accept banana jacks. These connectors can not be used to measure ac, dc, and ac + dc amperes, dc watts, and ac and ac + dc volt-amperes.

9 **Multiplexer Control Output** — These outputs provide control for the measurement modules' external multiplexers, which expand the module subchannels up to 64 for each module.

3.5 MEASUREMENT MODULES

Figure 3-7 shows the Measurement modules and their input connectors. The numbered items in figure 3-6 are keyed to the following descriptions. Option 50-1 module measures all functions; see paragraph 1.2.2. Option 50-2 module measures only Vdc, dBdc, temperature, and cold-junction temperature.

1 **Channel Number** — Channels are always 1 through 4 from left to right; your instrument may have any combination of Options 50-1 and 50-2 modules.

2 **Hi** — This Hi connector is used to measure ac and dc voltage, ohms, temperature, and frequency related functions.

3 **Lo** — This Lo connector is used to measure ac and dc voltage, ohms, temperature, frequency related functions, and ac or dc current up to 320 mA.

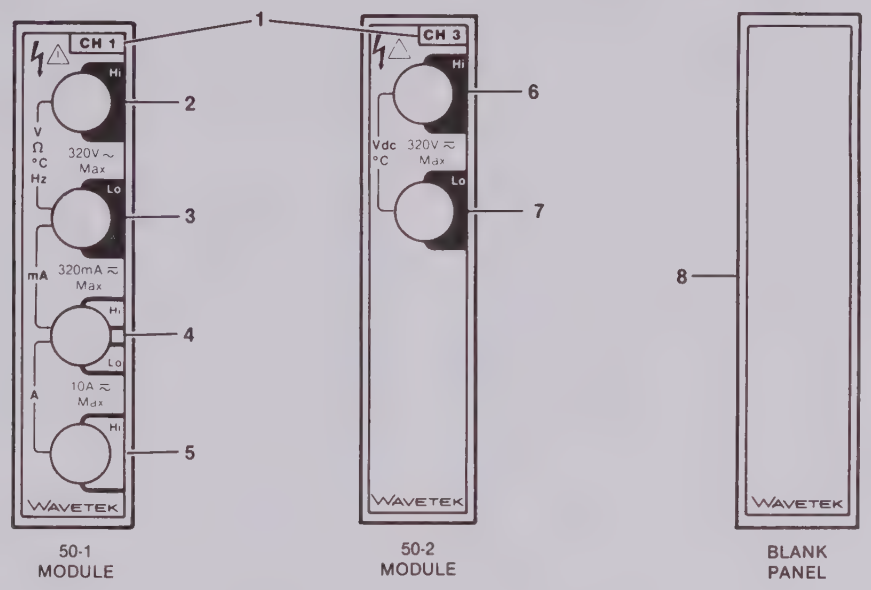


Figure 3-7. Measurement Modules

4 **Hi/Lo** — When used as Hi connector, it is used to measure ac or dc current up to 320mA. When used as Lo connector, it is used to measure ac or dc current up to 10A.

5 **Hi** — This Hi connector is used to measure ac or dc current up to 10A.

6 **Hi** — This Hi connector is used to measure volts dc, dBdc, and temperature.

7 **Lo** — This Lo connector is used to measure volts dc, dBdc, and temperature, and senses the cold-junction temperature.

8 **—** This blank panel covers an unused channel slot.

3.6 OPERATIONAL OVERVIEW

This section gives references to more detailed information from time to time. The section 4 references should be used if you contemplate local operation of the Model 52. Use the section 5 references if you plan on remote operation of your Model 51 or 52 (using GPIB or RS-232 communication port). Most operational concepts are covered in both sections 4 and 5, but with a different slant. If a concept is still unclear after reading the appropriate part of section 4, try consulting section 5. And vice-versa.

3.6.1 Models 51 and 52 Operation Compared

Model 52 Manual Operation

Operating the Model 52 data multimeter is not turning knobs, but pushing front panel keys to call up display screens, in which you then select items. The main menu (the first one you will see after turning on the power) contains items for selecting the operating mode, communication method, etc., and displays unit configuration, status, etc.

Models 51 and 52 Remote Operation

Remote operation does not use menus, but a series of commands. Almost every remote command has a menu equivalent. Each command has a sequence of parts which is roughly equivalent to the series of menus you would follow in manual setup.

Remote commands will often be referred to by their exact mnemonic (abbreviation). A clue that an abbreviated word such as **ALRM** refers to a remote command is that it will be highlighted in **bold**.

3.6.2 Operation Overview Introduction

The Models 51 and 52 data multimeters take, store, and transmit measurements, and provide external control signals based on the measurements. These functions can be combined and modified to perform various tasks. To use a Model 51 or 52 as a conventional DMM, after selecting the channel, you provide it with the traditional

function and range selection. By using the measurement function with the decision-making capability (ALARMS), the Models 51 and 52 become process controllers. (Most control applications will require one or more Digital I/O plug-in cards.) Adding storage to the measurement function gives you a data logger.

The Model 51 or 52 will often be referred to as "the unit" after this.

MEASURE

The data multimeter takes measurements using one of two modes: DMM (Digital Multimeter) mode, or CHANNEL LIST mode. The DMM mode makes continuous measurements of a single input. The channel list mode makes continuous measurements of one or more inputs and has an unique name that you assign; the channel list mode could be thought of as a multiple channel DMM. The PROGRAM mode makes measurements by controlling a separately-created channel list or lists; the "program's" measurements are taken beginning on conditions set up by you, repeat at intervals you specify, and stop under conditions you specify.

Measurements can be made using the measurement module input connectors or the Digital I/O input connections. Measurement modules measure 24 functions and with 4 measurement modules installed can be expanded to measure up to 260 inputs. The optional Digital I/O reads an 8-bit byte or a single bit. With all four digital I/O cards installed, you can read four bytes, 32 bits or a combination of each.

TRANSMIT

The Models 51 and 52 allow you to send real time or recalled measurements outside the unit. The measurements can be dumped over RS-232-C or IEEE-488 to an external device such as a printer or computer.

The optional Digital I/O cards can output eight-bit wide digital bytes that can be set up to track measurements. Each Digital I/O card also produces an analog output voltage that can be set up to track measurements ("store" measurements using a chart recorder).

CONTROL

The Models 51 and 52 can control external processes by making measurements, making one or more decisions based on those measurements, and controlling external devices, based on the decisions. The primary control outputs are from the optional Digital I/O cards which can provide output control bits, output control bytes, and analog output control voltages. A second set of "control outputs" may be the RS-232-C and IEEE-488 interface ports. These let the units become an integral part of a larger control system. The Models 51 and 52 make decisions using a feature called **alarms**. Setpoints, deadbands, etc. can be set up.

STORE

Measurements taken by the Models 51 and 52 can be stored either in (internal) **memory** or externally in another storage system. Internal memory is a battery-backed-up Random Access Memory (RAM). The number of measurements that can be stored depends on the size and number of channel lists and programs stored in the data multimeter.

Recall of previously stored data is controlled by menu selections, or equivalent remote commands.

3.6.3 Measurement, Control, and Data Logging Defined

3.6.3.1 Measurement Defined. . .and Display Modifiers

For our purposes, we will say that measurement, at its simplest, requires a process, something that converts the signal from the process to another form (measurement) and the display of the converted signal. We will also include the possibility that the unit doesn't display the reading, itself, but simply passes the readings on to something (such as a dumb terminal), that does. (Figure 3-8.) The Models 51 and 52 can modify the reading so that what is displayed (or transmitted) is in a different form. Most types of measurements can have these display modifiers (**DISP modifiers**, for short):

— SCALE — Manipulates the reading by a math formula and displays the result instead of the original reading.

— MIN — Displays only the minimum reading taken so far.

— MAX — Displays only the maximum reading taken so far.

— RES — Resolution of the reading can be specified to be other than a default degree of resolution.

— AVG — A number of readings can be averaged before the display is updated.

— DELTA — Displays the difference between the current reading and a value you specify.

(These "display mods" are discussed in detail in section 4.5.4.)

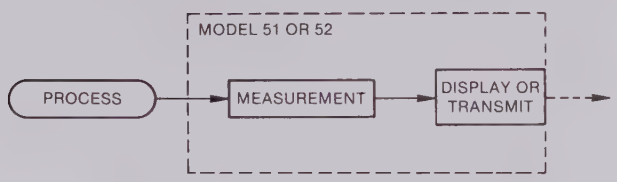


Figure 3-8. Measurement

3.6.3.2 Data Logging Defined. . .and Two Function Modifiers

Having defined measurement, we will note that data logging is measurement and storage (figure 3-9, Logging Storage). The flip side of storage is the recall of the data later, to be displayed or transmitted (figure 3-9, Logging Recall). These are minimum configurations — the measurements that are being stored could also be transmitted, processed and fed to chart recorders, etc.

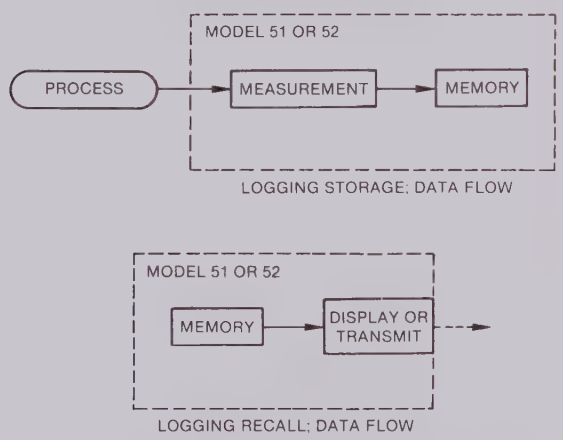


Figure 3-9. Data Logging

The Models 51 and 52, while having the capability of automatically changing functions that they are measuring, also can take each measurement with a different user-specified delay ahead of it. This is useful when the unit has changed the process, or just changed channels. To get this delay, after specifying a measurement channel, its function, and the range, you will also specify the delay. The **delay** we will call a **function modifier**, since it modifies how the unit takes the reading.

The unit, if it has a Digital I/O card, can take readings and drive a chart recorder with an digital or analog representation of a channel's measurements. This ability is called **tracking**. The representation of the measurement can be sent to any one of four card slots (5 through 8) that have a Digital I/O card in them. (Digital I/O card isn't a complete name, really, since a Digital I/O card also has an analog ("chart recorder") output on it. The digital or analog output channel that is to receive the "measurement" is usually specified at the same time as the measurement is set up. This specification (of the output channel number) is done after the measurement's channel number, function, and range are entered. Like DELAY, TRACKING is also called a **function modifier**.

For this manual, "transmit" or "transmission" will mean RS-232 or GPIB transmission. It won't mean output from an analog or digital I/O channel (slots 5 — 8), unless identified explicitly. Also, "output channel" will be referring to either an analog output or a digital output (port) on a Digital I/O card (slot 5, 6, 7, or 8).

3.6.3.3 Control Defined. . .and Alarm — the Third Common Function Modifier

Control is measuring a process, making a decision upon that measurement, and outputting one or more control signals that modify the process. Figure 3-10 is the minimum configuration to meet this definition. (Data logging, data transmission, etc., could also be going on at the same time.)

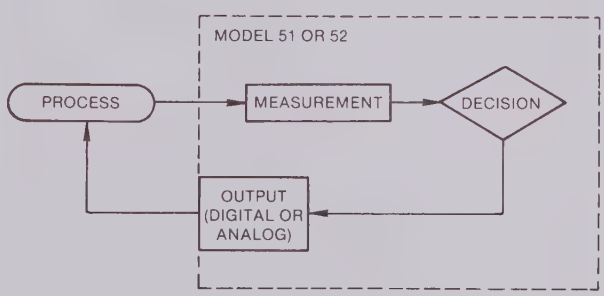


Figure 3-10. Control

Alarms

The unit can make a decision on a measurement by employing an **ALARM**. The first half of an alarm requires setting up a threshold (setpoint) or window. Then, when the measured quantity is above or below a certain amount, an alarm-response that is attached to the measurement-setup is activated.

The alarm can be set up to make one of four judgements on a measurement:

Is it less than a value?
Is it greater than a value?
Is it between two values?
Is it outside of two values?

The value or values can be any numerical quantity.

Creation of alarms is covered in detail in sections 4.5.5.2. and 5.7.4. When an alarm is attached to a measurement it is called a **function modifier**. Function modifiers

are discussed in more detail in sections 4.5.5 and 5.7.13 (table 5-5).

The Three Main Function Modifiers

Virtually all of the measurements that the Models 51 and 52 can make can have any combination of DELAY, TRACKING, and ALARM attached to them as function modifiers. One exception is a TIME reading: Only DELAY and ALARM can be function modifiers for TIME readings. The other exception is a TEXT channel reading — no function modifiers are allowed.

3.6.4 A Shorthand Notation

Model 51 and 52 programming concepts and programs will often be explained from here on using a shorthand form of notation. We won't bother drawing the process, and usually not the display or transmit function. Instead, we will concentrate on when and how many times the unit takes the measurement. So, figure 3-8 would now look like figure 3-11.

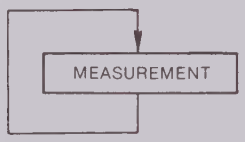


Figure 3-11. Continuous DMM Measurement-taking

Figure 3-11 has a loop around the measurement. Flowcharting is traditionally top to bottom, with blocks above performed before the blocks below. We will keep that tradition. So, the loop around the measurement block in figure 3-11 means that the measurement is performed, then it is repeated. Endlessly. Unless, of course, you turn the DMM off, or change the measurement parameters.

3.6.5 DMM

The Traditional DMM

A traditional DMM setup requires you to specify the **function** it is to measure, the **range**, and perhaps whether or not the readings are to be averaged before being displayed (**display modifier**). See figure 3-12.

The measurement "channel number" (1) is implied, and taken for granted, since the DMM has only one meter in its case to measure things with. It also requires you to specify the **DMM** to operate — Pressing the ON/OFF button. (The Model 52, since it has another mode besides DMM that might be used for entering measurement setups, requires you to *select* its DMM, if that's what you want to use.) Figure 3-13 summarizes the measurement-setup parameters for our hypothetical traditional DMM.

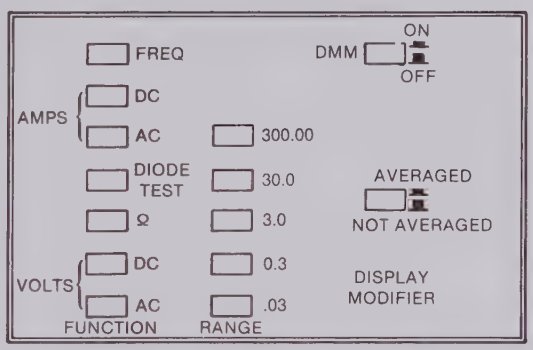


Figure 3-12. Traditional DMM

(Channel number is implied)
Function: VDC, VAC, etc.
Range: .03, 0.3, 3.0, etc.
Display Modifier (sometimes)

Figure 3-13. Traditional DMM Measurement-setup

The Models 51 and 52 DMM

The Models 51 and 52 also have the measurement-setup parameters of figure 3-13. Since they can potentially measure on several channels at once, you need to specify the **channel number** that the function, range, etc., apply to. If you can take advantage of other display modifiers besides averaging, they are available. (See paragraph 4.5.4.) It is optional whether or not you specify a function modifier.

The Model 52 does some averaging on the displayed reading, if a display modifier of AVG = 1 is not specified: The unit keeps a running average of the last five readings, and updates the display each time it takes a new measurement. (The Models 51 and 52 don't store or transmit this average — just each datum as it is acquired.)

The Models 51 and 52 also have function modifiers (explained later) that are optional to specify. Figure 3-14 gives the usual order of entry of the measurement-setup parameters for the DMM mode.

(Specify) **DMM** Mode
Channel Number
Function: VDC, VAC, etc.
Range: .03, 0.3, 3.0, etc.
Function Modifier (optional)
Display Modifier (optional)

Figure 3-14. Model 51 or 52 DMM Measurement-setup

(The only exception to the above order is a remote setup for a Digital I/O channel; the display modifier must come ahead of the function modifier.)

Like a traditional DMM, the settings in figure 3-14 are non-volitile; that is, the unit remembers the settings, even if turned off and on.

3.6.6 CHANNEL LIST

One of the things that sets the Models 51 and 52 apart from traditional DMMs is their ability to store several measurement-setups in memory, for convenient later use. This is the **channel list** mode. The measurement-setups in this mode have the same ingredients as in DMM mode — plus, each setup must be given a unique name. This is so an individual setup can be referred to later. The channel list mode allows several measurements with different functions, ranges, etc., to be taken in sequence or in parallel. To enter the channel list-setup mode in local with the Model 52, you would select the second item on the main menu. To enter the channel list-setup mode in remote, you would use the remote command **ENTL**.

Figure 3-15 gives the channel list ingredients for a channel list that does only one measurement.

(Specify) **CHANNEL LIST** Mode
Optional to specify : SERIAL or PARALLEL;
NAME for this list
Channel Number
Function: VDC, VAC, etc.
Range: .03, 0.3, 3.0, etc.
Function Modifier (optional)
Display Modifier (optional)

Figure 3-15. Channel List Parameters

Note the similarity to figure 3-14, the DMM setup. Only the first three items are different. CHANNEL LIST mode is specified, instead of DMM. And since it is a channel list, it needs a name. The unit will "file" this measurement setup in its memory under this name.

If there were more measurements to this list, (up to **64** measurements), they would be listed after the first measurement. (...Channel number, function, range, function modifier, display modifier;...channel number, function, range, function modifier, display modifier, etc.)

3.6.6.1 Serial vs. Parallel Channel Lists

Figure 3-16 shows three channel lists operating. The first list is taking measurements in sequence (a serial list). The second, a parallel list, is taking measurements on different channels.

In figure 3-16, as a example, measurement A could be a measurement of dc volts on channel (measurement module) 1, measurement B could be a measurement of ac volts on channel 2, and measurement X could be a measurement of time on channel 9. In the serial list, the measurements are taken one after another, with the process repeating endlessly. As soon as a measurement is converted, it is stored or transmitted (if storage or transmit is enabled). ("Transmitted" means sent to the transmission buffer area, which then proceeds at its own pace.)

With an integrating converter such as the Models 51 and 52 have in each measurement module, conversion of different voltages takes differing amounts of time. In the first parallel list, each measurement is taken as fast as possible, then repeats without waiting to see if the other measurements are done.

In the last parallel list of figure 3-16, measurements A and B are on the same channel. Obviously only one can be done at one time. So the unit will be alternating between measurements A and B, while measurement X proceeds in parallel at its own pace.

A parallel list is useful when you want quick updates of a measurement that occurs quickly, without being held up by a series of slower measurements on other channels in the list. A remote command of **READ** will cause *recent* data to be sent. Also, there is less chance of the unit returning an E8 code (data not ready).

Another feature of a parallel list is that all of the measurements will start at the exact same time on the first pass through the list. (Assuming each channel has only *one* measurement.) Storage and/or transmission will take place in the order the measurements are listed in the channel list listing. Transmission or storage of a reading will wait until that particular measurement has been converted (in whatever order).

With parallel, if there is *more than one* measurement of a channel, as soon as the first measurement on that channel is converted, the second measurement can begin, etc. Regardless of order of listing in the list. Again, storage and/or transmission of a datum will wait until there is a conversion for the measurement listed.

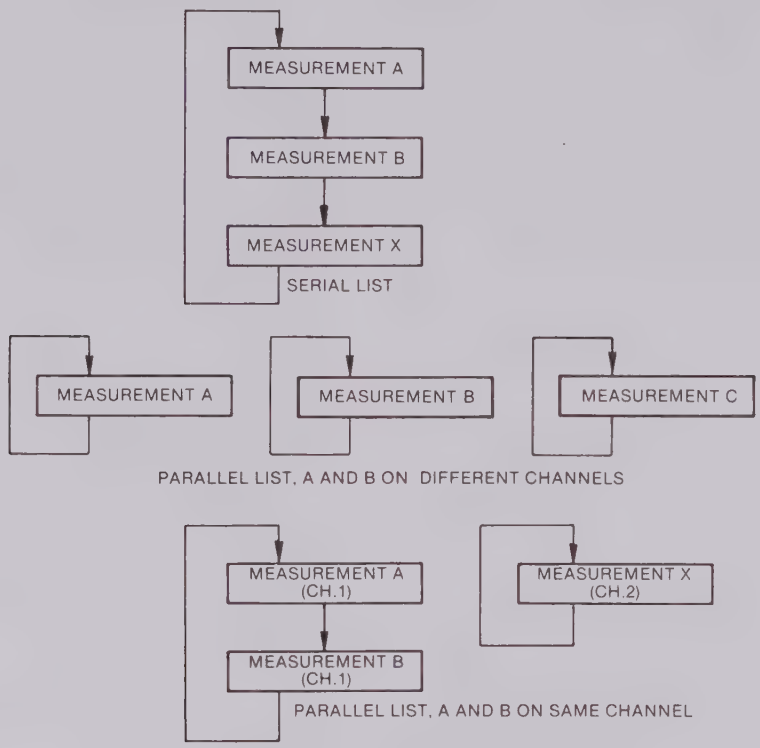


Figure 3-16. Serial and Parallel Channel Lists

Anytime there is more than one measurement on the same channel in a parallel channel list, the same-channel measurements will be taken in the order they are listed.

If sequence of measurements must be maintained, use a serial list. If you don't specify serial or parallel in the channel list setup, the unit will assume parallel.

3.6.6.2 Diagramming the Three Main Function Modifiers

Previously, ALARM, DELAY, and TRACKING were introduced as function modifiers to measurements. Now, a convenient symbology for diagramming them will be explained. Diagramming channel lists is a useful aid to understanding their interrelationships in actual applications.

Figure 3-17 shows a channel list of three measurements. (From here on, the serial form of channel list should be assumed, unless otherwise specified.) Since a diamond on a flowchart has been the traditional way of representing a decision, we will keep that tradition, and show ALARMS attached to measurements as diamonds.

The first measurement in the channel list has no alarm attached. The second measurement has an alarm that sends a value to an output channel if the alarm condition is true. The third measurement's alarm makes the unit's internal beeper go off if the alarm condition is true.

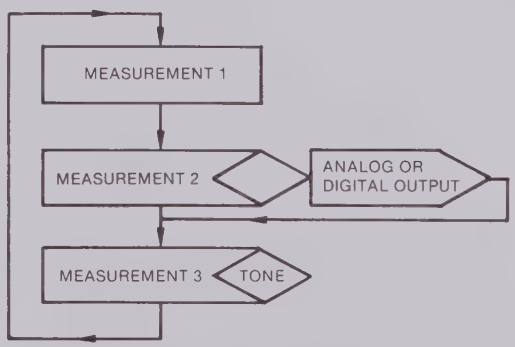


Figure 3-17. Channel List with Two Alarms

Figure 3-18 shows two channel lists. Channel List 1 has three measurements. When the unit comes to do the first measurement in the list, it waits a specified delay before beginning the measurement process. This is represented by the **D** in the block at the left of the measurement. When the unit comes to the second measurement in the list,

it again waits a delay. (This delay could be different from the first. Each measurement can have unique values for its alarm, delay, and tracking function modifiers.)

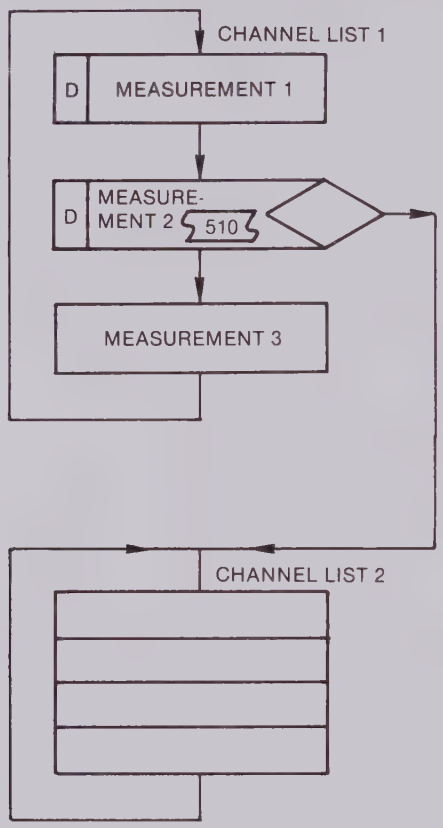


Figure 3-18. Channel List with Delays, Alarm, and Tracking

The squiggly box inside of measurement 2 means **tracking**. The digital output port on the I/O card in slot 5 is changing values as the measurement value changes. Instead of a digital output channel doing the tracking, we could have an analog output "port" doing the tracking. This would be useful for feeding a chart recorder, a servo, etc. Output channel numbering is explained in sections 4.5.1.2, 4.5.3, 4.5.5.3, 5.7.13, 5.7.28, and 5.7.29.

Measurement 2 also has an alarm attached. If the alarm condition is true, the response for this alarm is to start a different channel list.

3.6.6.3 Control with Channel Lists

Now to use our diagramming technique to show the conceptual "backbone" of an application. Figure 3-19 is a diagram of Alarm Example 3, in section 5. (The example is in paragraph 5.7.4, the **ALRM** command.)

Figure 3-19 shows a channel list of two measurements. Both have alarms attached. Only one thing had to be monitored (temperature). A measurement can have only one alarm attached. Since we needed two separate alarm-responses, the measurement had to be repeated so the second alarm could be attached. If the temperature is between 70° and 74°, neither alarm is true. If the temperature is equal to or greater than 74°, the first alarm's response is to send a logic LO to an output port. If the temperature is equal to or less than 70°, the second alarm responds, sending a logic HI to the output port.

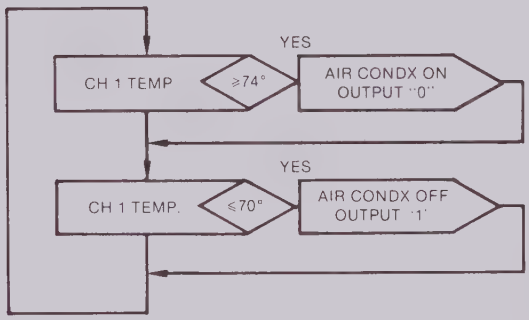


Figure 3-19. Alarm Example 3, Diagrammed

So, in a channel list of only two measurements, we can make a controller that has a deadband. In this case, the deadband was set to be 4°. The alarms are attached to the measurements by specifying alarm numbers for function modifiers to the measurements. The actual alarm conditions and responses are specified when the alarms are programmed separately. One set of condition and response is given a alarm number — the same number as the function modifier on the measurement.

In the above case, it is the alarms that send the HI or LO bit to the output port. There is an alternate approach that will accomplish the same thing if a deadband is not needed. See figure 3-20.

In figure 3-20, the output control bit is sent by a step in a channel list, not as a response to an alarm. The alarms' job in this case is to switch between the lists, so the appropriate output (HI or LO) will be written to the port. This structure is appropriate if the channel lists for different temperatures are to have measurements not in common. (Or other outputs that are not in common.)

If a deadband is required, this approach requires adding a third channel list. One channel list would operate when the temperature is below the deadband, one list would operate inside the deadband, and one list would operate above the deadband.

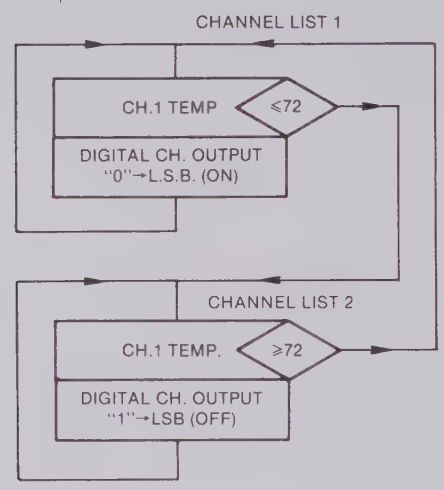


Figure 3-20. Two Alternating Channel Lists

3.6.6.4 Data Logging with Channel Lists

Each time a measurement is made, there is a new piece of data that could be displayed, stored, or transmitted. There are main menus that control the routing of the data, to make it be displayed, stored, or transmitted. For example, there is a main menu called DATA ROUTING (equivalent remote command is **DATA**) that plays a major role in selecting the types of data acquired by the unit to be stored or transmitted.

One important limitation of a channel list is that, by itself, it runs continuously. It is spewing out data, filling up memory, if you are data logging. Possibly the rapid rate of data acquisition threatens to fill up the unit's memory before your test is completed. The most DELAY you can insert between measurements in a channel list is 25.5 seconds... Or perhaps the event you want to log will occur when you can't be there... There is a capability of the Models 51 and 52 that lets us run channel lists when and how often we want. It is called the PROGRAM mode.

Stringing Channel Lists Together

Since channel lists can be stored in memory, it would be nice to be able to mix and match them like building blocks for various applications. And it would be nice to start and stop a custom setup of one or more channel lists at any time we want. If we were to diagram a setup of two lists, with a start and stop time when they run, it would look like figure 3-21.

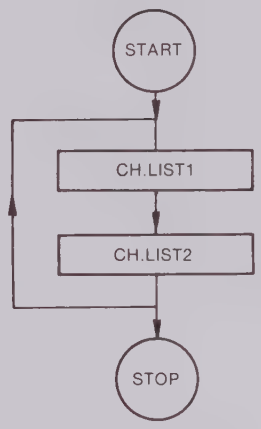


Figure 3-21. Two Channel Lists In Sequence

Something starts the channel lists in figure 3-21, and then they run continuously until something makes the arrangement stop. The arrangement takes each measurement listed in the first channel list, then takes each measurement in the second channel list. The number of scans through the lists is limited by whatever makes them stop. To show that a decision can be made to **stop after a certain number of scans**, we'll redraw the arrangement as figure 3-22.

This hypothetical structure lets us set up a condition which will start the channel lists running, and a condition which, if met, will stop the arrangement. Two useful items for a **start condition** would be a time, and an external electrical trigger. This new structure also lets us run one channel list more than once for each pass through the other channel list. The number of times a channel list repeats before going on to the next list we'll call the **repeat count**.

Useful items for a **stop condition** would be time, an electrical trigger, or a certain number of scans around the loop.

One more thing would be nice: to be able to pause for a lengthy period between scans of the channel lists. The name for this period is **scan interval**...

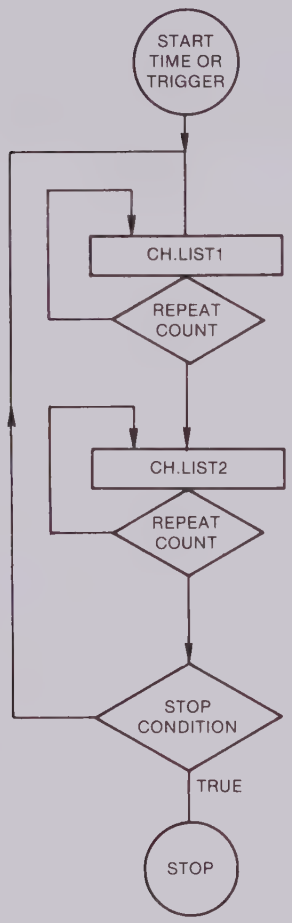


Figure 3-22. Hypothetical Program Structure

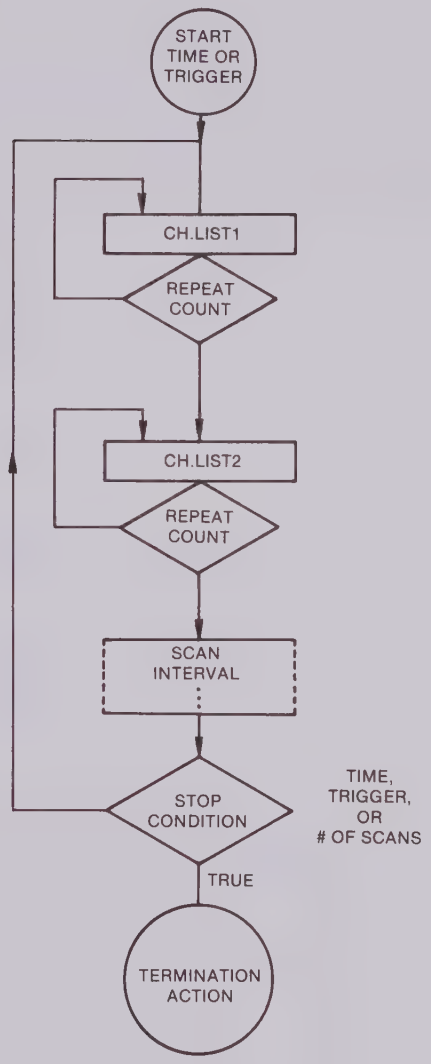


Figure 3-23. Models 51 and 52 Program Structure

3.6.7 The PROGRAM Mode (also known as Data Logging Mode)

The Models 51 and 52 have a "programming" mode for stringing channel lists togather with all of the aforementioned features. It is the **PROGRAM** mode. To enter the PROGRAM-setup mode, in local with the 52, you would select the third item on the main menu. In remote, you would use the **ENTP** command. The PROGRAM structure is shown in figure 3-23.

The number of lists in a Model 51 or 52 program may be from 0 to 255. After a program is completely finished (the circle marked **TERMINATION ACTION**), the unit may stop indeed — or run another program that you have specified.

The ability of a program to limit the number of data points acquired can be used to limit the number of points acquired **after an event**. And by using a memory management selection called WRAP, the number of data points acquired before the event is limited by the memory size. With WRAP we never "run out" of memory — when memory gets full, it just starts writing over old stored data, beginning with the earliest. One "pre-event" program or list takes data continuously before the event. Then the event happens, triggering an alarm which causes the switch to the "post-event" logging program.

After a preset number of channel list repeats and program scans (set by you), the program stops taking data. This approach is useful when the event is an analog quantity changing value slightly...

Note that the "event" could be something as simple as a handheld switch connected to a Digital input being closed or opened. There would be a line in the channel list just to read the input bit (0 or 1). The alarm is attached to that reading. The alarm threshold could be set for 0.5. Then when the switch is switched, the alarm is true. The alarm response is to run a program which takes the limited number of readings.

Another way to accomplish the above, which doesn't record the switch "readings", is to use a switch connected to a Digital EXTERNAL TRIG pin as a STOP CONDITION for the pre-event program. The pre-event program's TERMINATION ACTION is to RUN the post-event program.

The total number of channel lists plus programs in memory may not exceed 255.

Figure 3-24 shows the DMM, CHANNEL LIST, and PROGRAM component parts, and their relationship to one another.

To summarize: The DMM and CHANNEL LIST modes make measurements. (The only exception is doing an output to a Digital or Analog Output channel.) The PROGRAM mode puts controls on a channel list or lists with respect to start and stop conditions, repeat counts of channel lists, scan interval, number of scans, etc. Because of these controls, the PROGRAM mode is sometimes referred to as the "data-logging mode".

One more feature: One channel list can be designated as the **monitor channel list**. When the unit is in the scan interval of a program, instead of doing nothing, it can be made to run the monitor channel list. If monitor list operation during scan intervals is selected (MONITOR MODE menu), the monitor list will run continuously during any programs' scan intervals. The monitor channel list can be the same list that a program runs. A monitor list without an alarm will not store any of the data it acquires. So, a monitor list can be used to monitor and display or transmit a value or process during the scan interval, without filling up memory. Monitor list operation is diagrammed in figure 5-1 (paragraph 5.7.19).

You may want to have only certain classes of data in an application be stored. **Appendix C** summarizes some common choices made as to structure, modes, and menus, to achieve this result.

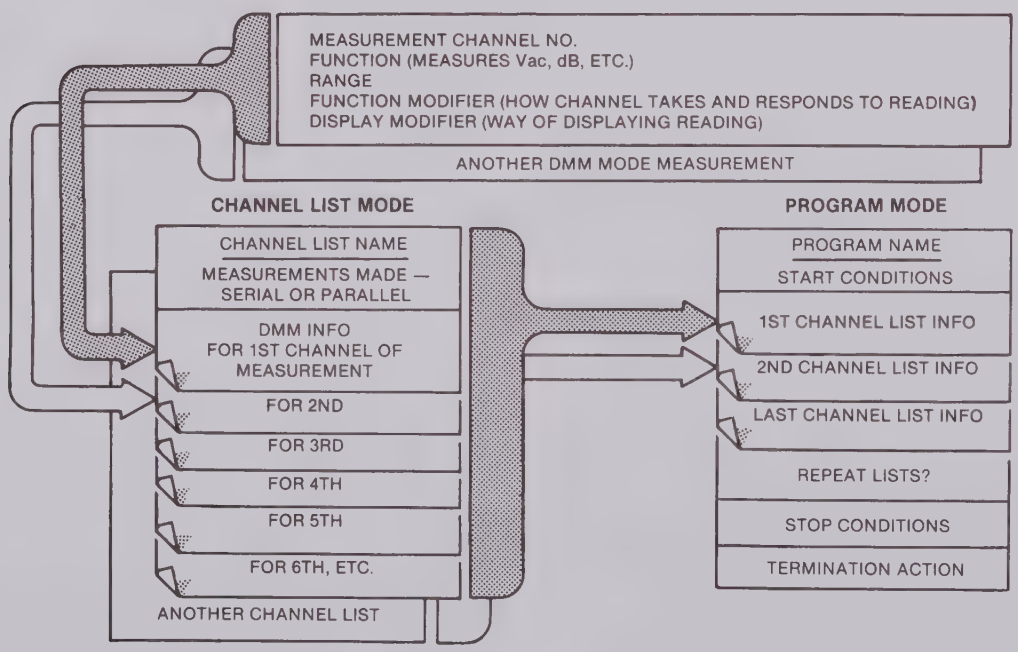
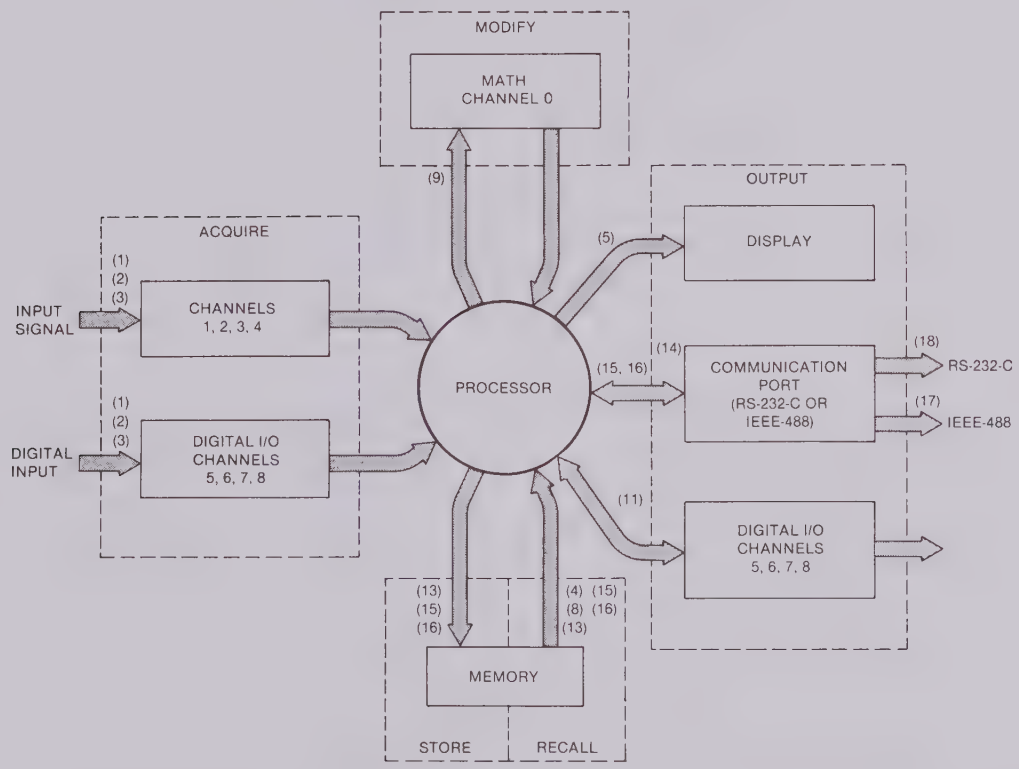


Figure 3-24. DMM, CHANNEL LIST, and PROGRAM Parts

Throughout this manual, "programming" will be used in a general sense to mean setting up the Model 51 or 52. The particular case may be only the DMM, a channel list, or it may require both the channel list and the program mode capability. If the PROGRAM mode is referred to, it will be clear from the context. "Program" will mean a Model 51 or 52 program. Also, "program" will not refer to a computer program or controller program written in another language such as BASIC, unless the phrase "computer program" or "controller program" is used.

3.6.8 Data Paths

The first three items in the Model 52 main menu are the three operating modes: DMM (Digital Multimeter), CHANNEL LIST, and PROGRAM. You must always select one of these main menu items in order to create a measurement-setup, regardless of what other main menu items you use. (Examples 3-1, 3-2, and 3-3 in paragraph 3.7 are introductory exercises, one example for each mode.)



Key	Main Menu Item	Details In Paragraph
(1)	DMM	4.5
(2)	CHANNEL LIST	4.6
(3)	PROGRAM	4.7
(4)	RECALL DATA	4.4.3
(5)	DISPLAY MODE	4.3.1
(6)*	MONITOR MODE	4.7.3.1
(7)	KEYBOARD LOCK	4.3.2
(8)*	TIME/DATE	4.5.1.3
(9)	MATH	4.5.1.5

*Not Shown

Key	Main Menu Item	Details In Paragraph
(10)*	ALARMS	4.5.5.1
(11)	TRACKING	4.5.5.3
(12)*	UNIT STATUS	4.3.5
(13)	MEMORY STATUS	4.3.3
(14)	CONFIGURATION	4.3.4
(15)	DATA ROUTING	4.4.1
(16)	TRANSMIT/MEM	4.4.2
(17)	IEEE-488	5.7.16
(18)	RS-232-C	5.7.21

*Not Shown

Figure 3-25. Data Paths

Now that we have a structure for taking measurements, how do we control where the readings go? The appropriate data paths must be set up. These are controlled by other main menus. These other "data path" menus are often (but not limited to) DATA ROUTING, TRANSMIT/MEM, DISPLAY MODE, RS-232-C, and IEEE-488. A specialized menu, ALARMS, also has (alarm response) selections that can affect data routing. Once we have stored data in the unit's memory, it can be recalled later using a main menu called RECALL DATA (remote command **RCL**). Figure 3-25 is an overview of the Models 51 and 52 in terms of data paths.

Figure 3-25 shows the paths that data can take within the data multimeter. Each path shown in figure 3-25 contains numbers in parentheses that refer to main menu items. Before making a measurement, you must decide how you want to manage your data. That is, before you make the measurement you must decide if you want to modify the data (math channel), store the data, transmit the data, or use the data to control some external device. The numbered main menu items in figure 3-25 key you to the appropriate paragraphs in sections 4 and 5. See also table 5-2 (paragraph 5.4).

3.7 MODEL 52 INTRODUCTORY EXERCISES

Examples 3-1, 3-2, and 3-3 are examples of operation in the three modes: DMM, CHANNEL LIST, and PROGRAM. Maximum benefit will be derived if you do the examples as exercises.

Remote operation introductory examples are in paragraph 5.3.

3.7.1 DMM Mode

The DMM (Digital Multimeter) mode allows you to do the job with only one instrument setup. The DMM mode just keeps measuring that one thing over and over. This is like the old-style meter with knobs that select only one function (such as ohms) and one range (such as 30K Ω) at a time. The input signal can be to any measurement module Hi/Lo connector pair (front or rear) or digital I/O channel (option positions 5 through 8, rear panel) connectors (see figure 3-9).

Example 3-1 demonstrates how to set up the Model 52 to measure a 1.5Vrms sine wave using the front panel input connector of Channel 2.

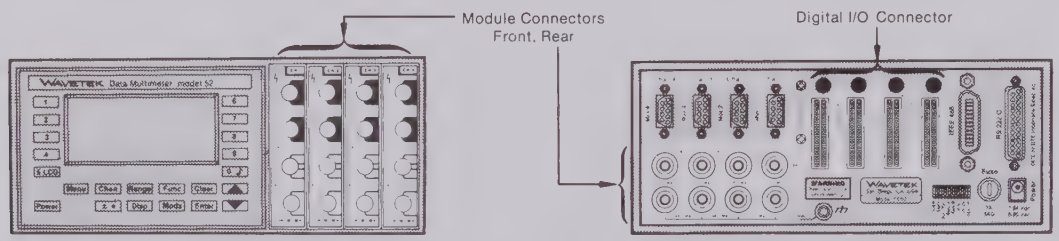
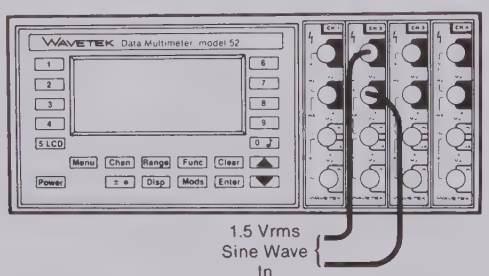


Figure 3-26. Connectors for Measurement Signal Input

Example 3-1. DMM Measurement

This example illustrates how to set up the Model 52 to measure a 1.5Vrms sine wave signal using the front panel input connector of Channel 2 (see paragraph 3.4). This example assumes that the signal has already been connected to the front panel input connector pair (Hi, Lo 320 Vac Max) of Channel 2.



Example 3-1. DMM Measurement (Continued)

Step	Display	Comments
Power		
1 Press **Power** on.	<DMM <CHANNEL LIST <PROGRAM <RECALL DATA	Pressing the Power key turns the Model 52 on and displays the main menu (see paragraph 4.2).
Mode		
Select the desired mode.		
2 Press the key to the left of "<DMM" to select the digital multimeter mode.	0.6767 1FP Vdc <Δ Δ%>	For details on the Digital Multimeter mode, see paragraph 4.5. Items Δ and Δ% displays the change (deviation) in a reading. For more details refer to paragraph 4.5.4.1, Delta.
Channel Number		
Select the channel number of the input connector pair being used.		
3 Press the **Chan** key.	ENTER CHAN #: _	
4 Press the **2** and **Enter** keys.	1.5045 2FP Vdc <Δ Δ%>	For details about channel numbers, see paragraph 4.5.1.
Function		
Select the type of measurement to be made.		
5 Press the **Func** key to call the function menu screen.	2FP 1.5045 Vdc ◀Vdc TEMP> <Vac OHMS> <Vac+dc dB>	For details about functions, see paragraph 4.5.2.
6 Press the key to the left of "<Vac".	2FP 1.3453 Vac <Vdc TEMP> ◀Vac OHMS> <Vac+dc dB>	
Range		
Select the measurement range.		
7 Press the **Range** key to call the range menu screen.	2FP 1.3453 Vac ◀AUTO 3V> <30mV 30V> <300mV 300V>	Each function has its own set of unique ranges; for details on ranges, see paragraph 4.5.2.
8 Press the key to the right of "3V>" to select the 3V ac range.	2FP 1.3453 Vac <AUTO 3V▶ <30mV 30V> <300mV 300V>	

Example 3-1. DMM Measurement (Continued)

Step	Display	Comments
Enter 9 Press the **Enter** key.	1.3453 2FP Vac <▲ ▲%>	The Enter key returns the display to the single channel DMM display.

3.7.2 Channel List/Multiple Channel DMM Mode

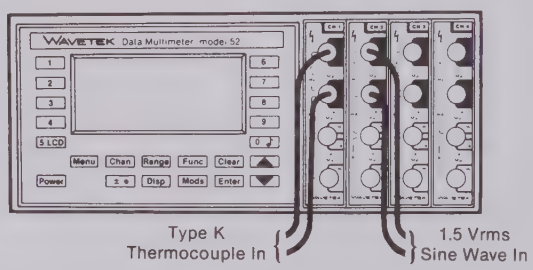
The channel list (multiple channel DMM) measures several things at the same time. A channel list can make up to 64 separate measurements. A channel list could measure, for example, a dc voltage, an ac current, a resistance, and a frequency all at the same time. The input signals can be connected to any measurement module Hi/Lo connector pair (front or rear) and digital I/O channel (option position 5 through 8, rear panel) connector (see figure 3-9).

Figure 3-8 shows the relationship between the channel list mode and the DMM mode. The "control settings" for a single channel measurement in a channel list are the same "control settings" required for the DMM mode (measurement channel number, function, range, etc.); see paragraph 3.5.1. The channel list can be used two ways: as part of a program (see paragraph 3.5.3) or as a multiple measurement DMM. All channel lists are identified by a user-entered name.

Example 3-2 demonstrates how to set up the Channel List mode. Paragraph 4.6 describes the channel list mode in detail.

Example 3-2. Channel List Measurements

The following example creates a channel list named "TEST" that measures a 3 Vrms signal on channel 2, temperature in degrees Fahrenheit on channel 1, and time on channel 9. This example assumes that the signal has already been connected to the front panel input connector pair (Hi, Lo 320 Vac Max) of Channel 2 and the thermocouple has already been connected to the front panel input connector pair (Hi, Lo 320 Vac Max) of Channel 1. Channel 9 requires no input connections.



Step	Display	Comments
Power 1 Press **Power**.	<DMM <CHANNEL LIST <PROGRAM <RECALL DATA	
Mode *Select the desired mode.* 2 Press the key to the left of "CHANNEL LIST".	NAME? ◀SERIAL PAR>▶ <USE ▲▼ KEYS> --------	For details on the Channel List (Multiple Channel DMM) mode, see paragraph 4.6.

Example 3-2. Channel List Measurement (Continued)

Step	Display	Comments
Channel List Name *Enter the name of the channel list.* 3 Use the ↕ cursor keys to locate "T" and press Enter, then "E" Enter, "S", Enter, "T", and Enter.	NAME? ◀SERIAL PAR> <USE ▲▼ KEYS> TEST____	A channel list when created must be assigned a user-entered name. This name identifies the channel list in the main menu or program listing. For details on channel list names, see paragraph 4.6.1.2. Channel lists may be run as serial (SERIAL) or parallel (PAR) list; serial is the default condition. For details abour serial and parallel lists, see paragraph 4.6.1.3.
Channel Number *Select the channel number of the input connector pair being used.* 4 Press Enter. 5 Press 2.	Ch: 2	For details about channel numbers, see paragraph 4.5.1.
Function *Select the type of measurement to be made.* 6 Press Func.	◀Vdc TEMP> <Vac OHMS> <Vac+dc dB>	For details about functions, see paragraph 4.5.2.
7 Press the key to the left of "<VAC".	<Vdc TEMP> ◀Vac OHMS> <Vac+dc dB>	
Range *Select the measurement range.* 8 Press Range.	◀AUTO 3V> <30mV 30V> <300mV 300V>	Each function has its own set of unique ranges; for details on ranges, see paragraph 4.5.2.
9 Press the key to the right of "3V".	<AUTO 3V▶ <30mV 30V> <300mV 300V>	
Enter 10 Press Enter.	2FP: Ch: _	The Enter key accepts the "control settings" and allows entry of the next set.

Example 3-2. Channel List Measurements (Continued)

Step	Display	Comments
Channel Number		
Select the channel number of the input connector pair being used.		
11 Press **1**.	2FP: Ch: 1	For details about channel numbers, see paragraph 4.5.2.
Function		
Select the type of measurement to be made.		
12 Press **Func**.	◀Vdc TEMP> <Vac OHMS> <Vac+dc dB>	
13 Press the key to the right of "TEMP"	<Vdc TEMP▶ <Vac OHMS> <Vac+dc dB>	For details about functions, see paragraph 4.5.2.
Range		
Select the measurement range.		
14 Press **Range**.	<K TC E> ◀J TYPE T>	Each function has its own set of unique ranges; for details on ranges, see paragraph 4.5.2.
15 Press the key to the left of "K".	◀K TC E> <J TYPE T>	
Enter		
16 Press **Enter**.	2FP:1FP Ch: _	The Enter key accepts the "control settings" and allows entry of the next set.
Time Channel		
Select channel number 9 to display the time and date.		
17 Press **9**.	2FP:1FP Ch: 9	The channel number 9 is designated as the time and date channel. For details on the time and date channel, see paragraph 4.5.1.3.
Function		
18 Press **Func**.	◀MM/DD HH/MM <HH:MM:SS <MM/DD/YY	
19 Press the key to the left of the "HH:MM:SS".	<MM/DD HH/MM ◀HH:MM:SS <MM/DD/YY	

Example 3-2. Channel List Measurements (Continued)

Step	Display	Comments
20 Press **Enter** twice.	"TEST.L" <DELETE RUN▶ XMIT-BIN> <EDIT LOCK>	This menu allows you to run, edit, delete, and transmit the channel list; for details, see paragraph 4.6.1.5.
Run		
Select RUN to begin taking measurements.		
21 Press the key to the right of "RUN>".	2FP 3.0001 Vac 1FP 22.9 °C 9 10:37:46 HMS	All three measurements are displayed at the same time.

3.7.3 Program Mode

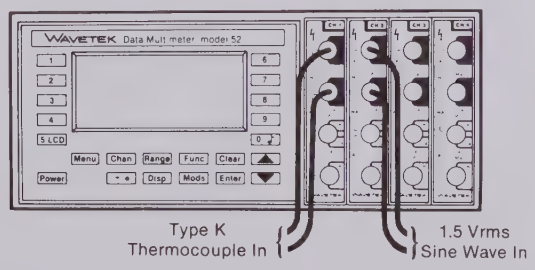
A program (data logger) makes measurements using existing channel lists. A programs begins on certain conditions, repeats at set intervals, and stops on certain conditions. Within the program, an individual channel list can be repeated up to 98 times, and the entire group of channel lists can be repeated up to 9998 times at intervals up to 100 days. At the end, the program could run another program.

Figure 3-8 shows the relationship between programs and channel lists. Programs do not make the actual measurements, but call existing channel lists, which in turn call up each assigned channel to make the measurements.

Example 3-3 demonstrates how to set up the program mode. Paragraph 4.7 describes the program mode in greater detail.

Example 3-3. Program Example

This example creates a program named "CHECK" which starts after 5 minutes, runs the channel list named "TEST" (see example 3-2) twice, waits 15 seconds, and repeats the channel list "TEST" twice. This cycle continues for 10 minutes. (The channel list "TEST", example 3-2, must be created before this program.) This example assumes that the 1.5 Vrms sine wave signal has already been connected to the front panel input connector pair (Hi, Lo, 320 Vac Max) of Channel 2 and the thermocouple has already been connected to the front panel input connector pair (Hi, Lo, 320 Vac Max) of Channel 1. Channel 9 requires no input connections. A program can store or transmit the readings as well as display them; the program in this example does not store or transmit the readings.



Step	Display	Comments
Power		
1 **Power** on.	<DMM <CHANNEL LIST <PROGRAM <RECALL DATA	

Example 3-3. Program Example (Continued)

Step	Display	Comments
Mode		
Select the desired mode.		
2 Press the key to the left of "<PROGRAM".	NAME? (USE ▲▼ KEYS) _____	For details on the program mode, see paragraph 4.7.
Program Name		
Enter the name of the program.		
3 Use the cursor keys to locate "C", then Press Enter. Next locate "H", press Enter, locate "E", press Enter, locate "C", press Enter, locate "K", and press Enter.	NAME? (USE ▲▼ KEYS) CHECK___	A program when created must be assigned a user-entered name. This name identifies the program in the main menu. For details on program names, see paragraph 4.7.1.2.
Enter		
4 Press Enter.	STRT DD HH:MM <▲t ▲00 00:00 <RTCLK ASAP> <⌐ EXTTRIG ¬>	The Enter key accepts the "control settings" and allows entry of the next Set.
Start Condition		
Select the conditions that start the program.		
5 Press the key to the left of "Δt".	STRT DD HH:MM ◀▲t ▲00 __:__ <RTCLK ASAP> <⌐ EXTTRIG ¬>	
6 Press 0, 0, 0, 0, 0, and 5.	<ΔT Δ00 00:05	For details on start conditions, see paragraph 4.7.1.3.
Channel List		
Select the existing channel lists to be used.		
7 Press Enter twice.	CALL: CH LIST> <TEST	For details on selecting channel lists for a program see paragraph 4.7.1.4.
8 Press the key to the right of "CH LIST"		
9 Press the key to the left of "<TEST". Press Enter.	CALL: CH LIST> <TEST ×01	

Example 3-3. Program Example (Continued)

Step	Display	Comments
Repeat Count *Select how many times each channel list repeats.* 10 Press the key to the right of "X01".	REPEAT COUNT? (1-99) __	For details on channel list repetitions, see paragraph 4.7.1.4.
11 Press **2** and **Enter**.	CALL: CH LIST> <TEST X02>	
Scan Interval *Select when the selected group of channel lists repeats.* 12 Press **Enter**.	SCAN INTERVAL: DD HH:MM:SS 00 00:00:00 <SET CONTIN▶	For details on setting up scan interval conditions, see paragraph 4.7.1.5.
13 Press the key to the left of "<SET".	SCAN INTERVAL: DD HH:MM:SS __ __:__:__ ◀SET CONTIN>	
14 Press **0**, **0**, **0**, **0**, **0**, **0**, **1**, **5** and **Enter**	SCAN INTERVAL: DD HH:MM:SS 00 00:00:15 ◀SET CONTIN>	
Stop Conditions *Select what stops the program.* 15 Press **Enter**.	STOP DD HH:MM <Δt Δ00 00:00 <RTCLK SCANS▶ <ʃ EXTTRIG 1>	For details on stop conditions, see paragraph 4.7.1.6.
16 Press the key to the left of "<Δt".	STOP DD HH:MM ◀Δt Δ__ __:__ <RTCLK SCANS> <ʃ EXTTRIG 1>	
Program End *Select what happens when the program ends.* 17 Press **0**, **0**, **0**, **0**, **1**, and **0**.	STOP DD HH:MM <Δt Δ00 00:10 <RTCLK SCANS> <ʃ EXTTRIG 1>	For details on program end conditions, see paragraph 4.7.1.7.
18 Press **Enter** twice.	PRGM END: <RUN-P/L STOP▶	

Example 3-3. Program Example (Continued)

Step	Display	Comments
19 Press the key to the right of "STOP>" Then press **Enter**	"CHECK" <DELETE RUN> XMIT-BIN> <EDIT LOCK>	
RUN		
Select RUN to begin the program.		
20 Press the key to the right of "RUN>.	CHECK 00001 ▲t=00 00:00:45 RT=00 11:25:32 <STOP MONITOR>	The first screen shows the monitor mode display.
	2FP 3.0001 Vac 1FP 22.9 °C 9 10:37:46 HMS	The second screen shows the reading display for a few seconds, and returns to the monitor mode display.
	CHECK 00002 ▲t=00 00:00:11 RT=00 11:25:47 <STOP MONITOR>	For details on running the program, see paragraph 4.7.3.

SECTION 4
MANUAL OPERATION

4.1 INTRODUCTION

In the operational overview (paragraph 3.6), you were introduced to some of the terms and operating concepts associated with the Model 52.

Paragraph 3.5 also introduced you to the three basic functions of the Model 52:

- Measuring Instrument
- Data Logger
- Process Controller

To set up the Model 52 to perform these functions, you must "link" together several operational blocks. The three primary blocks are Measure, Store, and Control.

Measure The Model 52 makes all the measurements of a general-purpose and special-purpose multimeter and reads digital inputs. It can measure one or several inputs continuously or based on control conditions (such as time or trigger inputs).

Store The Model 52 stores measurements, processed measurements, alarms, time, date, and text in its internal memory. The standard memory 9.6K bytes can store approximately 870 readings. The memory can be expanded to 768K that can store approximately 72,000 readings.

Control The Model 52 controls external devices using its optional digital and analog outputs.

There are other blocks that can be linked with these functions.

Communications Communications allows readings and stored data to be transmitted over the RS-232-C or IEEE-488 ports. The Model 52 can also be set up through the communication ports (Section 5).

Display Display allows readings and stored data to be shown on the Model 52's screen.

Math Math allows readings to be processed by an user-defined formula that makes five function calculations. The resultant from the formula can be displayed, stored, or transmitted.

Alarms Alarms monitor readings and respond when the readings meet user-defined conditions. Alarms allow decision making capabilities required for external control and measurement branching. Also, alarms can store or transmit exception data.

Table 4-1 describes how some of the blocks are linked together to perform the various functions. This table illustrates only the basic functions. These functions could be combined together for more complex operations. For example, a data logger and process controller could be linked together.

In table 4-1 each item that can be used with a block is listed along with paragraph references. Some items (Recall Data, Alarms, Tracking, Data Routing, Transmit/Memory, IEEE-488, and RS-232-C) must be set up before the measurements can be made and routed through the instrument.

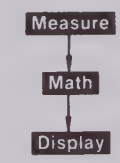
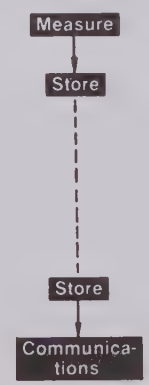
Some operational items are not listed in table 4-1. The following is a list of those items and their reference paragraphs.

Keyboard Lock	Paragraph 4.3.2
Time/Date	Paragraph 4.3.6
Tracking	Paragraph 4.5.5.3
Unit Status	Paragraph 4.3.5
Memory Status	Paragraph 4.3.3
Configuration	Paragraph 4.3.4

4.2 MENUS

While doing examples 3-1, 3-2, and 3-3 you learned that operating the Model 52 is not turning knobs or switches, but pushing front panel keys to call displays to the screen. These displays are called menus. Menus require you to select items or enter values or characters.

Table 4-1. Model 52 Operational Blocks

Function	Blocks	Purpose	Item	Reference Paragraph
Measuring Instrument		Measures and displays readings as taken.	Measure DMM Channel List Display Display Mode	 4.5 4.6 4.3.1
		Makes calculations based on measurement.	Math Math Scale	 4.3.7 4.5.4.1
		Measures and transmits as measurements are taken.	Measure DMM, Channel List, Program Communication Transmit/Mem Data Routing IEEE-488 RS-232-C	 4.5 4.6 4.7 4.4.2 4.4.1 5.10 5.8
Data Logging		Measures and stores measurements as taken.	Measure DMM Channel List, Program Store Data Routing Transmit/Mem	 4.5 4.6 4.7 4.4.1 4.4.2
		Recalls and transmits stored readings.	Store Recall Data Communications IEEE-488 RS-232-C	 4.4.3 5.10 5.8
Process Control		Monitors a measurement and when alarm conditions are met changes control conditions.	Measure DMM, Channel List, Program Alarms Alarm Control Digital OUtput	 4.5 4.6 4.7 4.5.5.2 4.5.1.2 4.5.3.3 4.5.3.4

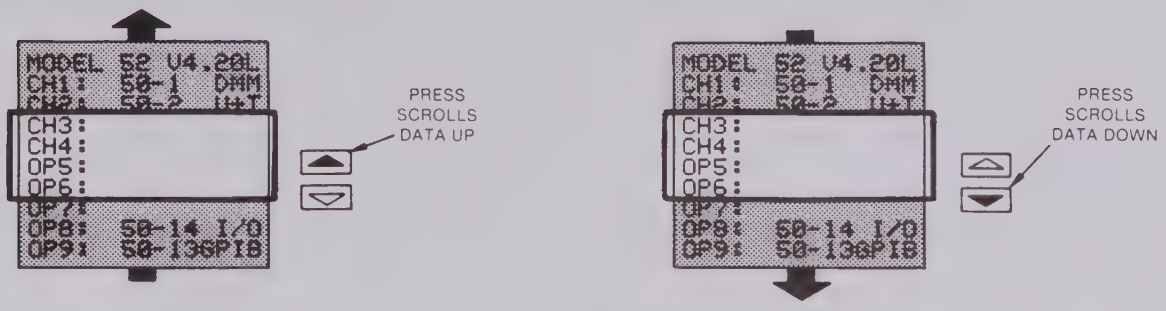


Figure 4-1. Menu Scrolling

The first menu shown at power on is the main menu display. The main menu contains 18 items grouped four at a time that select the Model 52's operating mode, communication methods, etc. and shows the unit configuration, status, etc. Appendix D lists and describes all items in the main menu and references other parts of this section that describe the menu items in detail. Appendix D also shows the "quick display" keys that skip to groups of main menu displays.

Remote vs Manual

Remote operation does not use menus but a series of commands and mnemonics. Almost every command has an equivalent menu. Thus each command string is roughly the equivalent of the series of menus you follow to set up the Model 52.

Scrolling

To move (scroll) to groups of items not shown on the screen but that are part of the display, use the ▲ ▼ cursor keys (see figure 4-1). Pressing the ▲ cursor key moves the display up. Pressing the ▼ cursor key moves the display down. Some menu displays (usually identified by ▲ ▼ on the screen) can also be scrolled by pressing the key that called the menu. For example, the function menu for the Option 50-1 measurement module has four sets of function menu displays; each time the Func key is pressed the screen advances to the next function menu display.

Special Feature

When readings are displayed and scrolled, press the Enter key to stop the scrolling. Press the Enter key again to resume the scrolling.

Selecting Menu Items

Menu items are selected by pressing the numeric keys surrounding the display (see figure 4-2). Menu items point (<, >) to the key that select that item. If an "arrow" is solid (◄), the menu item is already selected. Figure 4-2 shows that "Vdc" was selected and that pressing 3 selects "Vac", 8 selects "OHMS", etc.

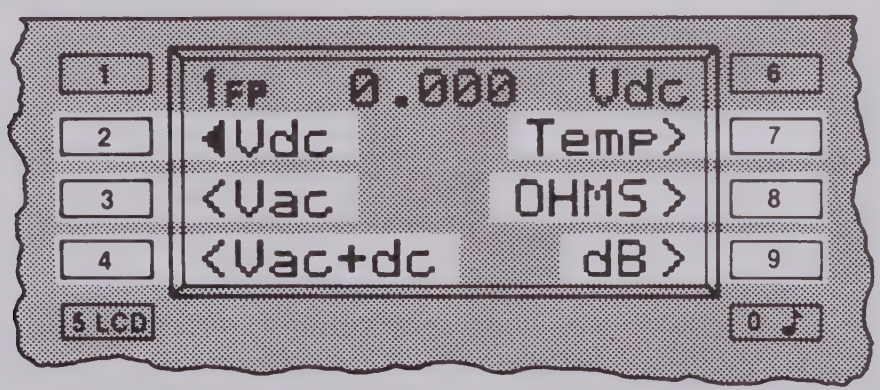


Figure 4-2. Selecting Menu Items

4.3 CONTROL AND CONDITION

These main menu items (Display Mode, Keyboard Lock, Monitor Mode, Unit Status, Memory Status, and Configuration) are used to control Model 52 and verify its condition.

4.3.1 Display Mode

Display Mode allows you to select how the displays are shown on the screen and how fast the the displays change (scroll speed).

To set up the Display Mode:

1. From the main menu, press the Disp key to locate DISPLAY MODE.
2. Select DISPLAY MODE. The display becomes:

```
<1CH      HOLD>
<4CH      SLOW>
           MED>
<OFF      FAST>
```

3. Select the desired display features (see table 4-2).

Table 4-2. Display Mode Item

Item	Result of Selecting Item
1CH	Displays one measurement reading (DMM display).
4CH	Displays four measurement readings (multiple channel DMM display).
OFF	Disables the display; this speeds up the measurement rate.
HOLD	Scrolling displays. Use ▲ ▼ cursor keys to advance the display when desired.
SLOW	Automatically scrolls the display at 2.3 seconds per reading. The ▲ ▼ cursor keys can be used to rapidly advance to the next display.
MED	Automatically scrolls the display at 1.0 seconds per reading. The ▲ ▼ cursor keys can be used to rapidly advance to the next display.
FAST	Automatically scrolls the display at 0.5 seconds per reading. The ▲ ▼ cursor keys can be used to rapidly advance to the next reading.

When the displays are not scrolling, the display mode can be changed by pressing the 8 key. This key will toggle the display between DMM and multiple channel DMM.

4.3.2 Keyboard Lock

Keyboard lock allows you to use a numeric code of up to four digits to lock out all front panel keys except Power. The front panel keys remain locked out even when the unit is powered off and powered back on. If the code is forgotten, the keyboard lock code can be removed by holding down the Clear key while turning on the power.

CAUTION

Power on-clear deletes all stored readings, channel lists, programs, alarms, and math channel formulas, and resets the Model 52 to its default conditions.

To lock the keyboard:

1. From the main menu, press the Disp key to locate KEYBOARD LOCK.
2. Select KEYBOARD LOCK. The display is:

```
LOCK CODE?

____
```

Use the numeric keys to directly enter the code, or you can use the ▲ ▼ cursor keys to cycle through the numbers. Repeat the process until you have entered all the digits, then press Enter key to accept the code. The Clear key can be used to change all or part of the code (providing Enter has not been pressed. Enter gives the following display:

```
*LOCKED*
UNLOCK CODE?
____
```

To unlock the front panel keys, use the numeric or ▲ ▼ cursor keys the same way as when the code was created. If you make an error, use the Clear key to edit. Press Enter to accept the code. If the code is correct, the screen shows the main menu display.

4.3.3 Memory Status

Memory Status answers the question "How full is the user memory"?

To review the memory status:

1. From the main menu, press the Range key to locate MEMORY STATUS.

2. Select MEMORY STATUS. A typical status display follows (see table 4-3 for interpretation):

```
R FREE      9378
A DATA         1
M PRGM       237
  TOTAL     9616
```

Table 4-3. Memory Status Items

Item	Description
FREE	Size in bytes of the unused memory.
DATA	Size in bytes of the used data (readings) memory.
PGRM	Size in bytes of the used program and channel list memory.
TOTAL	Total capacity in bytes of the memory.

4.3.4 Configuration

Configuration lists the options installed in the Model 52. This listing also gives the software version number.

To review the configuration:

1. From the main menu, press the Range key to locate CONFIGURATION.
2. Select CONFIGURATION. The following is a typical CONFIGURATION listing. Use the ▲ ▼ cursor keys to step through the listing. See table 4-4 for interpretation.

```
MODEL52 V4.23G
CH1: 50-1  DMM
CH2: 50-1  DMM
CH3: 50-2  V+T
CH4:
OP5: 50-14 I/O
OP6: 50-14 I/O
OP7:
OP8: 50-13GPIB
OP9: 50-12-128
BATT 50-11 RCH
```

Table 4-4. Configuration Items

Item	Description
MODEL 52 V4.23G	Model 52, software version 4.23G
CH1, CH2, CH3, and CH4	Option number and type of measurement module installed in channel 1 – 4 locations.

Table 4-4. Configuration Items (Continued)

Item	Description
OP5, OP6, OP7, OP8, and OP9	Option number and type of option cards installed in rear panel option 5 – 9, locations. For details on option card configuration, see paragraph 1.2.9.
BATT	Option number and type of battery installed.

4.3.5 Unit Status

Unit Status shows the date of calibration and allows selection of the line rejection frequency and the power saver mode.

To view the unit status:

1. From the main menu, press the Range key to locate UNIT STATUS.
2. Select UNIT STATUS. The following is a typical display. See table 4-5 for interpretation.

```
 LAST CAL:
   02/25/87
<PWR SAVE
<50Hz     60Hz▶
```

Table 4-5. Unit Status Items

Item	Description
LAST CAL	Date the unit was last calibrated.
PWR SAVE	When selected, only the channels to be measured are powered. There is a 2 second power stabilization delay before making measurements from the time the list is started until the first measurement is made. When power saver is not selected, all channels are powered on as long as the Model 52 is powered on and there is no delay before making the measurement.
50 Hz	When selected, 50 Hz line frequency is rejected. Only one line rejection can be selected.
60 Hz	When selected, 60 Hz line frequency is rejected. Only one line rejection can be selected.

4.3.6 Setting Time and Date

The TIME/DATE menu allows you to set the Model 52's real time clock. The real time clock runs on an internal battery, thus the clock continues to run without external power. If the internal battery fails and needs replacement (see Section 7) or if clock power has been removed (see paragraph 2.3.9), the time and date will need resetting.

To set the time and date of the Model 52 clock:

1. Press **Power** to turn the Model 52 on.
2. From the main menu, press **Disp** to locate TIME/DATE.
3. Select TIME/DATE. A typical display is:

```
22:38:45
◄TIME    DATE►
<SET
```

4. Select TIME.
5. Select SET. The display is:

```
TIME?
   HH MM SS
   --:--:--
```

6. Enter the time using the numeric keys. Enter the hours first (24 hour clock) followed by the minutes and seconds.
7. Press the **Enter** key to enter the new time.
8. Select DATE.
9. Select SET. The display is:

```
DATE?
   MM DD YY
   --.--.--
```

10. Enter the date using the numeric keys. Enter the month first (1 – 12) followed by the day and (last two digits) year.
11. Press the **Enter** key to enter the new date.

The **Clear** key erases unentered numbers. The **Menu** key returns to the previous menu.

4.3.7 Creating Math Formulas

Up to 99 math formulas may be defined. The math formula can be used as a channel reading or to scale a reading. See paragraph 4.5.8 for the use of math channels.

To create a math formula:

1. Press **Mods** to locate MATH in the main menu.
2. Select MATH. The display is:

```
      MATH
NUMBER    LABEL
(1-99)   "MATH"
   --
```

3. Math formulas are contained in the math channel (channel 0). Individual formulas are identified by subscripts to 0, such as 0_{12}. Enter the subscript (any subscript between 1 and 99 is valid). Channel number 0 is assumed.
4. Enter the formula. See table 4-6 and Example 3-4.
5. Enter the Math channel label. See **Label** in table 4-6.
6. Press **Enter** to accept the new formula and return to the main menu.

Table 4-6. Math Channel Conventions

Item	Description
Chan	Use this key to enter channel numbers and subscripts into the formula. If a channel entry is made without a subscript, the Model 52 assumes front panel inputs.
Range	Use this key, with the **Chan** key, to select a specific channel reading, otherwise the formula uses the first occurance of the channel reading. For example, if a channel list contains two measurements of Channel 2_{FP}, the first measuring Vdc and the second measuring Vac, and the formula uses the Vac measurement; pressing **Chan** **2** **Range** **2** (displayed as 2:#2) selects the second measurement of channel 2_{FP} for the formula. **Chan** **2** **Range** **1** will be displayed as "2:" (selecting the first measurement does not display "#1").
Enter	This key accepts the entry of an individual item in the formula. A second **Entry** (without a value or function before it) terminates the formula creation.

Table 4-6. Math Channel Conventions (Continued)

Item	Description
Func	This key allows the ▲ ▼ cursor keys to scroll through the functions that are scrolled in the following order: **+**, **−**, *****, **/**, "**(**", "**)**", **X** and √. "**X**" is a variable used when scaling (see paragraph 4.5.4.1) a channel reading. When the desired function found, press the Enter key once.
± •	This key serves two functions. When entering numbers, the ± • key enters decimal points (for example: 11.4). When not entering a number, the ± • key turns a cursor (flashing underline) on and off for deletion; see Clear.
Clear	This key deletes elements of the formula or the entire formula. If the cursor (____) is flashing, the Clear key deletes portions of the formula by backspacing over the elements (channel numbers, variables, functions, and constants). If the cursor is off, the Clear key will give this display: DELETE? <YES NO> Selecting YES will delete the entire math channel.
Constants	Constants are entered using the digits keys. Fractional decimal constants (<1.000) must be prefixed with 0 (for example, use 0.1234, not .1234). To enter a negative number in the formula, use the Func key to enter the function listing and use the ▲ ▼ cursor keys to select "−"
Label	The last Math Channel screen allows assigning a four letter math channel label for the formula. To enter the label, use the ▲ ▼ cursor keys to cycle through the characters (**A**, **B**, **C**, **D**, **E**, **F**, **G**, **H**, **I**, **J**, **K**, **L**, **M**, **N**, **O**, **P**, **Q**, **R**, **S**, **T**, **U**, **V**, **W**, **X**, **Y**, **Z**, ⌟, \, ⌜, ∧, □, ____, <blank>, **!**, "**,** **#**, **$**, **%**, **&**, ', **(**, **)**, *****, **+**, "**,**", **-**, "**.**", **/**, **0**, **1**, **2**, **3**, **4**, **5**, **6**, **7**, **8**, **9**, **:**, **;**, **<**, **=**, **>**, **?**, and **@**), and use the Enter key to accept the character and advance to the next character. The default label is MATH.
General	A math function may contain up to 132 characters. Up to 20 levels of parentheses may be used. Floating point values are truncated to 5 decimal places. Fractional decimals must be prefaced with "0". No spaces are permitted in the formula.

Example 4-1 illustrates how to create a math channel formula. Example 4-2 illustrates how to edit a math channel formula. Example 4-3 illustrates how to delete a math channel formula.

Example 4-1. Creating a Math Channel Formula to Calculate Inter-Channel Relationships

The following example adds the readings from channels 1_{FP} and 2_{00} and divides the result by the reading from channel 3_{FP}. The result is expressed as a percentage.

Step	Action	Display
1	From the Main Menu, select MATH.	<MATH <ALARMS <TRACKING <UNIT STATUS
2	Press 1 and Enter to enter the math formula number.	MATH NUMBER LABEL (1-99) " % " 01
3	Press the Func key, use the ▲ ▼ cursor keys to locate "(" and press Enter.	01=(
4	Press the Func key, use the ▲ ▼ cursor keys to locate "(" and press Enter.	01=((
5	Press the Chan key and 1.	01=((1:
6	Press the Func key, use the ▲ ▼ cursor keys to locate +, and press Enter.	01=((1:+
7	Press the Chan key, 2, 0, 0, and Enter.	01=((1:+2:00
8	Press the Func key, use the ▲ ▼ cursor keys to locate ")" and press Enter.	01=((1:+2:00)
9	Press the Func key, use the ▲ ▼ cursor keys to locate "/", and press Enter.	01=((1:+2:00) /
10	Press the Chan key and 3.	01=((1:+2:00) /3:
11	Press the Func key, use the ▲ ▼ keys to locate ")", and press Enter.	01=((1:+2:00) /3:)
12	Press the Func key, use the ▲ ▼ keys to locate "*", and press Enter.	01=((1:+2:00) /3:)*
13	Press 1, 0, 0, and Enter. This enters the constant 100.	01=((1:+2:00) /3:)*100
14	Press Enter once again.	ENTER LABEL "MATH" ----------
15	Use the ▲ ▼ keys to locate "%" and press Enter.	%----------
16	Press the Enter key to accept the label. (Display reverts to main menu upon the completion of the formula.)	<MATH <ALARMS <TRACKING <UNIT STATUS

To edit a math formula:

Any existing formula can be edited or reviewed by recalling the formula from the math menu. Only the math channels already entered are displayed. These formulas can be reviewed by using the ▲ cursor key to step through the numbers. Example 4-2 corrects an existing formula. Example 4-3 deletes an entire formula.

Example 4-2. Editing a Math Channel

Step	Action	Display
1	From the Main Menu, select MATH.	<MATH <ALARMS <TRACKING <UNIT STATUS
2	Select the Math formula 01.	MATH NUMBER LABEL (1-99) " % " 01
3	Press the Enter key (A blinking cursor appears at the end of the formula.)	D01=((1:+2:00) /3:)*100
4	Press the Clear key four times.	D01=((1:+2:00) /
5	Press Chan, 2, and Enter.	D01=((1:+2:00) /2:
6	Press the Func key, use the ▲ ▼ keys to locate ")", and press Enter.	D01=((1:+2:00) /2:)
7	Press the Func key, use the ▲ ▼ keys to locate "*", and press Enter.	D01=((1:+2:00) /2:)*
8	Press 1, 0, 0, and Enter. This enters the constant 100.	D01=((1:+2:00) /2:)*100

Example 4-3. Deleting an Entire Formula

Step	Action	Display
1	From the Main Menu, select MATH.	<MATH <ALARMS <TRACKING <UNIT STATUS
2	Select the Math formula 01 and press Enter.	MATH NUMBER LABEL (1-99) " % " 01
3	Press ±• to stop the blinking cursor.	D01=((1:+2:00) /2:)*100
4	Press the Clear key.	DELETE? <YES NO>
5	Press the key to the left of YES. (Display reverts upon completion of deletion.)	<MATH <ALARMS <TRACKING <UNIT STATUS

4.4 DATA HANDLING

Data handling answer the question "What to do with the measurements". The data handling items of the main menu (Data Routing, Transmit/Memory, and Recall Data) affect the storage and transmission of readings. Data Routing selects the storage and transmission of channel list, program, and alarm readings. Transmit/Memory selects when the readings are transmitted and whether the memory is to be filled or wrapped with new data. If you expect to store or transmit readings made by channel lists (DMM mode too) or programs, you must select these data handling items before making the measurements. Recall Data displays, clears, or transmits readings that have already been stored.

4.4.1 Data Routing

Data routing controls the storage and transmission channel list, program, and alarm readings. To set data routing:

1. From the main menu, press **Range** key to locate DATA ROUTING.
2. Select DATA ROUTING. The display is:

```
XMIT      STORE
<  CH LISTS  >
<  PROGRAMS  >
<   ALARMS   >
```

Items from the XMIT (left) side of the menu select what readings will be transmitted over the enabled RS-232-C or IEEE-488 ports (see paragraph 5.3, RS-232-C or 5.4, IEEE-488). Items from the STORE (right) side of the menu select what readings will be stored in memory. More than one menu item from each side can be selected. But, no matter how many items are selected, there will be no duplication of stored or transmitted readings. If nothing is selected (< not solid), nothing is transmitted or stored. See table 4-7 for further interpretation.

Table 4-7. Data Routing Items

Item	Result of Selecting Item
XMIT CH LISTS	Transmits channel list readings.
XMIT PROGRAMS	Transmits only channel list readings called in programs.
XMIT ALARMS	Transmits alarm readings. Alarm readings depend on the "Transmit Mode" conditions set up when creating an alarm.

Table 4-7. Data Routing Items (Continued)

Item	Result of Selecting Item
STORE CH LISTS	Stores channel list readings.
STORE PROGRAMS	Stores program readings.
STORE ALARMS	Stores alarm readings. Alarm readings depend on the "Store Mode" conditions set up when creating an alarm.

4.4.2 Transmit/Memory

Transmit/Memory selects when the readings are transmitted or stored. Transmit/Memory also selects how the memory is filled.

To set transmit time and memory fill modes:

1. From the main menu, press **Func** key to locate TRANSMIT/MEMORY.
2. Select TRANSMIT/MEMORY. The display is:

```
<CONTIN   *MEM*
<MEMFULL  WRAP▶
<ENDPRGM  FILL>
<&CLEAR
```

Items from each side of the menu can be selected. The left side selects when the data is transmitted. Data also can be cleared from memory when it is transmitted. The other side (MEM) selects how the memory is filled. One item from each side must be selected. See table 4-8 for interpretation.

Table 4-8. Transmit/Memory Items

Item	Result of Selecting Item
CONTIN	Continuously transmits readings over the enabled communications port.*
MEMFULL	Transmits stored readings over the enabled communications port when the memory is filled.
ENDPRGM	Transmits stored readings over the enabled communications port at the end of the program.
&CLEAR	When selected along with CONTIN, MEMFULL, or ENDPRGM, automatically clears readings from memory after the reading has been transmitted.

*Selecting CONTIN can slow the reading rate.

Table 4-8. Transmit/Memory Items (Continued)

Item	Result of Selecting Item
WRAP	When data fills the memory, new data begins writing over the existing stored data starting with the first data entered.
FILL	Data fills the memory until full. New data is no longer stored once the memory is filled. This is the power on clear default condition.

4.4.3 Recall Data

Recall Data allows you to display, clear, or transmit readings that have already been stored.

To recall data:

1. From the main menu, press **Menu** key to locate RECALL DATA.
2. Select RECALL DATA. The display is:

```
RCL DATA  CH#>
<CLEAR  SCAN#>
<DISPLAY TIME>
<XMIT  ALARM#>
```

The right side of the menu sorts readings by channel number, scan number, time, or alarm number. Another item (ALL data) can be selected by not selecting any of the four sort items (> not solid). The left side of the menu clears, displays, or transmits the sorted readings Items from the right side of the menu must be selected before the items from the left side. See table 4-9 for interpretation.

There are three ways readings can be stored relative to time:

1. Include Channel 9 (time/date) in a Channel List.
2. Use a Program that automatically includes the time as a part of each scan.
3. Use an Alarm that stores the reading and time.

Table 4-9. Recall Data Items

Item	Result of Selecting Item
CH#	Selects the readings by an entered channel number to be cleared, displayed, or transmitted.
SCAN#	Selects the readings by an entered scan number to be cleared, displayed, or transmitted.

Table 4-9. Recall Data Items (Continued)

Item	Result of Selecting Item
TIME	Selects the readings made at or after an entered time to be cleared, displayed, or transmitted.
ALARM#	Selects the reading by an entered alarm number to be cleared, displayed, or transmitted. To clear, display, or transmit all alarm readings, enter 0 for the alarm number.
ALL	ALL is not a menu selected item, but, all readings can be cleared, displayed, or transmitted. ALL is selected by not selecting items on the right side of the menu.
CLEAR	Deletes the selected readings.
DISPLAY	Displays the selected readings.
XMIT	Transmits the selected readings.

CLEAR ALL is the fastest way to clear the memory because clearing by group requires sorting and reorganizing the memory that slows down the process.

4.5 DMM MODE

The DMM (Digital Multimeter) Mode measures a single input. This paragraph introduces channel numbers, functions and ranges, digital I/O channels, display modifiers, and function modifiers. To set up DMM "control settings", follow these steps (illustrated in figure 4-3):

1. From the main menu, press **Menu** to locate DMM.
2. Select DMM.
3. Enter the Channel number (paragraph 4.5.1).
4. Select a Function (paragraph 4.5.2).
5. Select a Range (paragraph 4.5.2).
6. If necessary, select a Display Modifier (paragraph 4.5.4).
7. If necessary, select a Function Modifier (paragraph 4.5.5).

Function Modifiers (Mods) affect how the unit takes or responds to a reading. Those function modifiers common to all channels or functions are described in paragraph 4.5.5. Function modifiers unique to a channel for function are described with the channel or function.

Display Modifiers (Disp) alter how the readings are displayed or stored. Those display modifiers common

to all channels or functions are described in paragraph 4.5.4. Display modifiers unique to a specific channel or function are described with the channel or function.

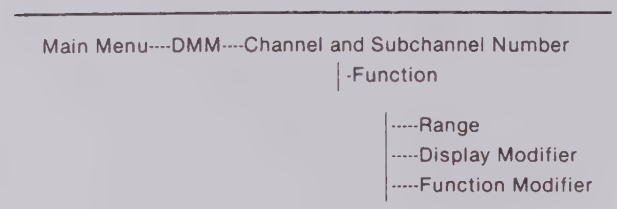


Figure 4-3. DMM Menu Tree

4.5.1 Channels Numbers

Model 52 identifies measurement modules, digital I/O cards, time, text, and math formulas by channel numbers. Measurement modules are assigned the first four numbers (Channels 1, 2, 3, and 4). The digital I/O cards are assigned the second group (Channels 5, 6, 7, and 8). Channel 9 displays the time/date. Channel 0 is used for text and math channels (user-defined formulas). Most channels can be further divided into subchannels. The screen displays the channel number as a large digit and the subscript numbers as the smaller digits. Table 4-10 lists the channel, subchannel, and other subscript numbers.

Table 4-10. Channels and Subchannels

Channel Number	Channel Function	Channel Subscript	Subscript Meaning
0	Text Channel	None	None.
0xx	Math Channel	1 through 99 (example: 0_{31})	Subchannel number: Up to 99 user-defined formulas.
1 2 3 4	Measurement Module	FP (example: 1_{FP})	Front panel input.
		00	Rear panel input.
		01 through 64	Subchannel number for a Multiplexed rear panel input.
5 6 7 8	Digital Input/ Output (I/O)	00	8 bit input.
		10	8 bit output.
		01, 02, 03, 04, 05, 06, 07, 08	Individual input bits in an 8-bit byte (01 = LSb).
		11, 12, 13, 14, 15, 16, 17, 18	Individual output bits in an 8-bit byte (11 = LSb).
		90	Analog output.
9	Time/Date	None	None.

4.5.1.1 Channel Numbers — Measurement Modules and Multiplexer

Entering a Channel Number and Subscript — Press the Chan key then the number keys. The first digit entered is the channel number, and the next two digits identify the subscript. Pressing Enter accepts the new channel number and subscript number. If only one subscript digit is entered, the entry is accepted as the least significant digit (for example, entry Chan 1, 9, is channel 1, subchannel 9. The entry is displayed as 1_{09}).

Front Panel Measurement Module Inputs — For front panel inputs, only the channel number need be entered; front panel inputs are identified on the display as subscript FP.

Rear Panel Measurement Module Inputs — For rear panel inputs, enter the channel number followed by 00 (subscript 00); rear panel inputs are identified on the display as subscript 00.

Multiplexed Measurement Module Inputs — Channels 1 through 4 can be expanded by up to 64 subchannels each by using the 8/16 channel multiplexers (Accessory 50-20). Paragraph 2.3.7 describes setting up the multiplexer. From the multiplexer setup, determine the channel and subchannel numbers and enter them as channel number and subscript. When measuring temperature with a multiplexer, every set of subchannel numbers for each multiplexer module must include at least one cold-junction temperature measurement.

4.5.1.2 Channel Numbers — Digital I/O Channels

Digital I/O channel numbers are entered exactly the same way as measurement module numbers in the previous paragraph. The subscript numbers determine the "function" of the channel (table 4-9).

When subscript 00 is entered (for example: 6_{00}), the Model 52 reads the 8-bit byte at the digital I/O connector. An individual bit (x) can be read by entering subscript 0X; subscript 0X identifies the bit location (1 to 8) in the 8-bit byte; for example, 7_{06} is channel 7 reading bit 6 at channel 7 I/O connector.

Entering subscript 10 writes (outputs) a (8-bit) Byte to the digital I/O connector. An individual bit (x) can be written to the digital I/O connector by entering subscript 1X; subscript 1X identifies the bit location (1 to 8) in the byte; for example, 7_{16} is channel 7 writing bit 6 to the channel 7 I/O connector.

Entering subscript 90 writes an 8-bit analog output voltage which can vary from 0 to 2.55V.

4.5.2 Functions and Ranges

This section describes the functions and ranges measured by the Model 52. These functions and ranges are used in the DMM mode and Channel List/Multiple Channel DMM mode. Table 4-11 summarizes the functions and ranges used with the measurement modules.

1. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List/Multiple Channel DMM).
2. Enter the channel number (paragraph 4.5.1).
3. Press Func to select the function (table 4-11).
4. Press Range to select the range.

Table 4-11. Measurement Functions, Ranges and Modules

Function	Description	Range[1]	Measurement Module		Paragraph Number
			50-1	50-2	
Vdc	Measure dc Volts	30mV – 300V + AUTO	•	•	4.5.2.1
Vac	Measure true rms volts		•		4.5.2.2
Vac + dc	Measure ac + dc Volts		•		4.5.2.3
dB	Measure ac dBm, dBW, rel dB, dBV		•		4.5.2.4
dBdc	Measure dc dB			•	4.5.2.8

[1]Ranges shown are in decade steps unless otherwise noted

Table 4-11. Measurement Functions, Ranges and Modules (Continued)

Function	Descritpion	Range[1]	Measurement Module		Paragraph Number
			50-1	50-2	
TEMP	Temperature measurement using external thermocouples	Type K, J, E, T.	•	•	4.5.2.5
OHMS	Two and four wire resistance measurement	30 – 300k + AUTO 3M – 3000M + AUTO	•		4.5.2.6
CONT	Continuity. Displays resistance and sounds tone (keyboard beeper enabled) when reading <10% of range.		•		4.5.2.7
FREQ	Measures frequency	10Hz – 1MHz, 4 + MHz + AUTO.	•		4.5.2.9
PERIOD	Measures period.	100μs – 1000ms + AUTO	•		4.5.2.13
TI, PW, TI...1Shot PW...1Shot[2]	Time interval and Pulse Width Repetitive or single pulse	100μs – 360s + AUTO	•		4.5.2.10 4.5.2.11
CJ TEMP	Temperature of channel's cold junction reference terminal.	NONE	•	•	4.5.2.16
⊣▶⊢ CHK	Measures diodes forward bias voltage in 5 dc current ranges.	100nA – 1mA	•		4.5.2.12
EVENTS	Counts up to 9,999,999 events dc to 800 kHz.	NONE	•		4.5.2.14
LOGIC	Measure logic levels (HI or LO)	NONE	•		4.5.2.15
Adc, Aac Aac + dc	Measure ac, dc or ac + dc	30mA – 10A. + mA AUTO and A AUTO	•		4.5.2.17 4.5.2.18 4.5.2.19
Wdc, VAac, VAac + dc	Measure Watts dc Volt-Amperes ac or Volt-Amperes ac + dc	30V and 300V. 300mA, 3A and 10A	•		4.5.2.20 4.5.2.21 4.5.2.22

NOTES:

[1]Ranges shown are in decade steps unless otherwise noted.

[2]Time interval is measured from the rising or falling edge of a front panel input to the falling edge of an external input (using a Digital I/O card).

The following paragraphs describe each function of the Model 52. All menu trees or examples assume the operating mode has already been selected. Display or function modifiers unique to a function are described with the function. All modifiers common to all functions are described in paragraphs 4.5.4 and 4.5.5.

When making multiple measurement on the same channel, some delay should be added to allow the measurement module to settle before making the next measurement.

4.5.2.1 DC Voltage

The following steps illustrate how to set up the Model 52 to measure dc voltage.

1. Press Power to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the Func key to call the function menu, and select "Vdc".
5. Press the Range key to call the range menu, and select the desired range. Table 4-12 lists the ranges for dc voltage.
6. If needed, press the Disp key to call the display modifier menu (see paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the Mods key to call the function modifier menu. Function modifiers alter how readings are taken and how the Model 52 responds to the reading. The only function modifiers unique to the dc voltage function is "Z = 10MΩ" which allows you to select a lower input impedance on the 30mV, 300mV, and 3V ranges. For details on other function modifiers, see paragraph 4.5.5.

On the 30mV, 300mV and 3V ranges, you can select two input impedances: 10MΩ or 1000MΩ (default input impedances on these ranges). You will find the 1000MΩ input impedance useful when measuring high impedance circuits where a 10MΩ input impedance would load down the circuit. For example, measuring a circuit which has a 1MΩ circuit impedance with a 10MΩ input impedance will introduce a 10% loading error while the 1000MΩ input impedance causes negligible loading error.

The 10MΩ is handy when using probes and voltage dividers that are specified to work into 10MΩ. On the 30V and 300V ranges, the input impedance is fixed at 10MΩ.

When the 1000MΩ input impedance is selected and no input applied, environmental noise may cause the Model 52 to display "OVRRNGE".

Figure 4-4 shows the front and rear panel input connections used to measure dc volts. Table 4-13 lists the input specifications for the dc voltage function.

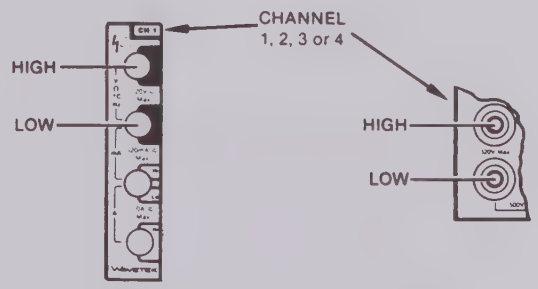


Figure 4-4. Front and Rear Panel Input Connections

Table 4-12. DC Voltage Ranges

Item	Range	Maximum Resolution	Default Input Impedance	Selectable Input Impedance
30mV	1μV to 32mV	1μV	>1000MΩ	10MΩ
300mV	10μV to 320mV	10μV	>1000MΩ	10MΩ
3V	100μV to 3.2V	100μV	>1000MΩ	10MΩ
30V	1mV to 32V	1mV	10MΩ	None
300V	10mV to 320V	10mV	10MΩ	None
AUTO	(Autorange) automatically ranges up to the next higher range at 32.000mV, 320.00mV, 3.2000V, and 32.000V and ranges down to the next lower range at 30.00V, 3.000V, 300.0mV, and 30.00mV.			

Table 4-13. Input Specifications

Item	Description
Measurement Module	50-1 or 50-2.
Coupling	DC.
Inputs	Front and rear.
Impedance	1000MΩ (30mV, 300mV, and 3V ranges). See dc voltage function modifiers. 10MΩ with <50pF shunt capacitance (30V and 300V ranges).
Voltage (Max)	± 450Vdc or peak ac continuous. Inputs protected against 6kV transients less than 10μs wide. Maximum voltage to chassis ground ± 450Vpk.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7 for single ended or differential inputs.

4.5.2.2 AC Voltage

The ac voltage measures the ac coupled component of a signal using a true rms method. This method allows accurate measurement of not just harmonic-free sinusoid waveforms, but waveforms with mixed frequencies, modulated signals, square waves and pulses. The ac voltage function is useful in measuring the ac ripple on a dc voltage (power supply ripple, phone line ripple, etc.). The following steps illustrates how to set the Model 52 to measure ac voltage.

1. Press Power to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the Func key to call the function menu, and select "Vac".
5. Press the Range key-to call the range menu, and select the desired range. Table 4-14 lists the ranges for ac voltage.
6. If needed, press the Disp key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the Mods key to call the function modifier menu. Function modifiers alter how readings are taken and how the Model 52 responds to the reading; see paragraph 4.5.5.

Table 4-14. AC Voltage Ranges

Item	Range	Maximum Resolution
30mV	3mV to 32mV	1μV
300mV	30mV to 320mV	10μV
3V	300mV to 3.2V	100μV
30V	3V to 3V	1mV
300V	30V to 320V	10mV
AUTO	(Autorange) automatically ranges up to the next higher range at 32.000mV, 320.00mV, 3.2000V, and 32.000V and ranges down to the next lower range at 30.00V, 3.000V, 300.0mV, and 30.00mV.	

Crest Factor expresses the ability of an instrument to accurately measure a wide variety of waveforms. The Models 51 and 52 allow crest factors of up to 3 at full scale of range and up to 11 at 1/3 of range full scale. Excessive crest factor casuses measurement error. Crest factor is a ratio of a waveforms most extreme maximum peak value to its rms value. Figure 4-4A illustrates the crest factor for several waveforms.

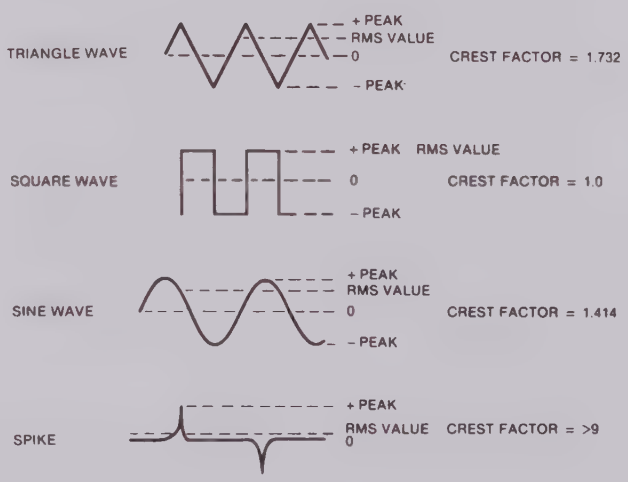


Figure 4-4A. Crest Factors

If you do not know the crest factor of a waveform you want to measure:

1. Measure the waveforms rms value on a Model 51 or 52.
2. Measure the waveforms 0 to extreme peak value using an ac coupled oscilloscope.
3. Divide the extreme peak value (step 1) by the rms value (step 2) to calculate the crest factor.

Figure 4-4 shows the front and rear panel input connections used to measure ac volts. Table 4-15 lists the input specifications for the ac voltage function.

Table 4-15. Input Specifications

Item	Description
Measurement Module	Option 50-1 or 50-2.
Coupling	AC.
Inputs	Front and rear.
Impedance	1MΩ with <50pF shunt capacitance.
Voltage (Max)	± 450Vdc or peak ac continuous for 20 seconds on 3V, 300mV, and 30mV ranges. Maximum voltage to chassis ground ± 450Vpk. Volts-hertz product $\leq 10^7$.
Input Protection	Inputs protected against 6kV transients less than 10ms wide.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7 for single ended or differential inputs.

4.5.2.3 AC +DC Voltage

The ac + dc voltage function allows measurement of total true rms voltages of waveforms with both dc and ac components (such as an dc offset wine wave) ($V_{RMS} = 1(Vac^2 + Vdc^2)$). This function should be used only when needed because it is not as accurate as using the ac voltage and dc voltage function alone. For example, this function cannot be used to measure just the ripple voltage of a power supply, as the dc voltage will sum with the ripple voltage. The following steps illustrate how to set up the Model 52 to measure ac + dc voltage.

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the **Func** key to call the function menu, and select "Vac + dc".
5. Press the **Range** key to call the range menu, and select the desired range. Table 4-16 lists the ranges.
6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the **Mods** key to call the function modifier menu. Function modifiers alter how readings are taken and how the Model 52 responds to the reading (paragraph 4.5.5.).

Table 4-16. AC + DC Voltage Ranges

Item	Range	Maximum Resolution
30mV	3mV to 32mV	1μV
300mV	30mV to 320mV	10μV
3V	300mV to 3.2V	100μV
30V	3V to 32V	1mV
300V	30V to 320V	10mV
AUTO	(Autorange) automatically ranges up to the next higher range at 32.000mV, 320.00mV, 3.2000V, and 32.000V and ranges down to the next lower range at 30.00V, 3.000V, 300.0mV, and 30.00mV.	

Figure 4-4 shows the front and rear panel input connections used to measure ac + dc volts. Table 4-17 lists the input specifications for the ac voltage function.

Table 4-17. Input Specifications

Item	Description
Measurement Module	Option 50-1.
Coupling	DC.
Inputs	Front and rear.
Impedance	1MΩ with <50pF shunt capacitance.
Voltage (Max)	± 450Vdc or peak ac continuous for 20 seconds on 3V, 300mV, and 30mV ranges. Maximum voltage to chassis ground ± 450Vpk. Volts-Hertz product $\leq 10^7$.
Input Protection	Inputs protected agains 6kV transients less than 10μs wide.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7 for single ended or differential inputs.

4.5.2.4 Decibels dB (AC)

The Model 52 makes decibel (dB) measurements by making ac voltage measurements and converting the reading to dBm (dB relative to 1mW), dBW (dB relative to 1W), or dBV (dB relative to 1V) equivalent. The Models 51 and 52 use a two-wire bridging mode which assumes the reference resistance is part of the measurement. The dB ranges are the same as Vac. The following steps illustrate how to set up the Model 52 to measure ac decibels.

1. Press Power to turn the Model 52 on.
2. Select the mode (see paragraph 4.5, DMM; see paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the Func key to call the function menu, and select "dB".
5. Press the Range key to call the range menu, and select the desired range. Table 4-18 lists the ranges.
6. If needed, press the Disp key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the Mods key to call the function modifier menu. Function modifiers alter how readings are taken and how the Model 52 responds to the reading. The function modifier items dBm, dBW, and "Z" (reference impedance) are unique to the dB function are described under SPECIAL CASES; all other function modifiers are described in paragraph 4.5.5.

Table 4-18. Decibel Ranges

Item	Range	Maximum Resolution
30mV	3mV to 32mV	1μV
300mV	30mV to 320mV	10μV
3V	300mV to 3.2V	100μV
30V	3V to 32V	1mV
300V	30V to 320V	10mV
AUTO	(Autorange) automatically ranges up to the next higher range at 32.000mV, 320.00mV, 3.2000V, and 32.000V and ranges down to the next lower range at 30.00V, 3.000V, 300.0mV, and 30.00mV.	

Figure 4-4 shows the front and rear panel input connections used to measure dB. Table 4-19 lists the input specifications for the decibel function.

Table 4-19. Input Specifications

Item	Description
Measurement Module	50-1.
Coupling	AC.
Inputs	Front and rear.
Mode	Two-wire bridging mode which mean the Model 52 has a high impedance input and assumes the reference impedance is connected externally.
Impedance	Menu selected.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7 for single ended or differential inputs.

SPECIAL CASES

dBm Measurements

Decibels relative to 1mW measurements are made by selecting dBm from the Function Modifier menu (paragraph 4.5.5). dBm is the logarithmic ratio of an ac voltage relative to the voltage required to produce 1mW into the reference impedance. Use the ▲ ▼ cursor keys to select the reference impedance: 50Ω, 75Ω, 90Ω, 93Ω, 110Ω, 125Ω, 135Ω, 150Ω, 250Ω, 300Ω, 500Ω, 600Ω, 600Ωrn, 800Ω, 900Ω, 900Ωrn, 1000Ω, 1200Ω (rn — relative to a noise level 90dB below the standard into 600 or 900Ω). 600Ω is the default impedance.

dBW Measurements

Decibels relative to 1W measurements are made by selecting dBW from the Function Modifier menu (paragraph 4.5.5). dBW is the logarithmic ratio of an ac voltage relative to the voltage required to produce 1W into the reference impedance. Use the ▲ ▼ cursor keys to select the reference impedance: 2Ω, 4Ω, 8Ω, and 16Ω. 8Ω is the default impedance.

Relative dB Measurements

Relative dB measurements are the logarithmic ratio of an ac voltage to a relative value. The relative value is set by selecting ΔRDG or ΔNUM from the Display Modifier menu (paragraph 4.5.4). ΔRDG uses the current **reading** to represent the relative value (0.00dB). ΔNUM allows **keypad entry number** of a relative value to represent 0.00dB. Relative dB can be either dBm or dBW. Both delta readings can also be made in %.

dBV Measurements

Decibels relative to 1 volt measurements are made by selecting dBm and 1000Ω from the function modifier menu. dBV measurements are the logarithmic ratio of an ac voltage relative to 1V into 1000Ω which is equivalent of dBm in 1000Ω.

4.5.2.5 Temperature

The Model 52 measures temperature using J, K, E, and T type (range) thermocouples. Software provides thermocouple linearizations for four types (J, K, E, T) of thermocouples. The cold-junction temperature (see paragraph 4.5.2.16) allows calculation of temperature using other types of thermocouples. The following steps illustrate how to set up the Model 52 to measure temperature.

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the **Func** key to call the function menu, and select "TEMP".
5. Press the **Range** key to call the range menu, and select the desired range. Table 4-20 lists the ranges. The temperature ranges select the thermocouple types.
6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the **Mods** key to call the function modifier menu. Function modifiers alter how readings are taken and how the Model 52 responds to the reading. The function modifier items °C, °K, and °F (table 4-21) are unique to the temperature function. All other function modifiers are described in paragraph 4.5.5.

Table 4-20. Thermocouple Guide

ANSI	Alloy Combination		Color Coding Thermocouple Grade					Maximum Useful Temperature	Limits of Error (Whichever is Greater) Standard	Comments Environment-
Code	+ Lead	– Lead	USA	Germany	UK	Japan	France	Range	Special	Bare Wire
J	Iron Fe	Constantan Copper-Nickel Cu-Ni	+ White – Red Jacket- Brown	+ Red – Blue Jacket- Blue	+ Yellow – Blue Jacket- Black	+ Red – White Jacket- Yellow	+ Yellow – Black Jacket- Black	32 to 1382°F 0 to 750°C The Model 52 supports J TCs to – 200°C	2.2°C or 0.75% 1.1°C or 0.4%	Reducing, Vacuum Inert. Limited Use in Oxidizing at High Temperatures. Not Recommended for Low Temperatures
K	Chromel Nickel-Chromium Ni-Cr	Alumel Nickel-Aluminum Ni-Al	+ Yellow – Red Jacket- Brown	+ Red – Green Jacket- Green	+ Brown – Blue Jacket- Red	+ Red – White Jacket- Blue	+ Yellow – Purple Jacket- Yellow	– 328 to 2282°F – 200 to 1250°C	2.2°C or 0.75% Above 0°C 2.2°C or 2.0% Below 0°C 1.1°C or 0.4%	Clean Oxidizing and Inert Limited Use in Vacuum or Reducing Wide Temperature Range Most Popular TC Type
T	Copper Cu	Constantan Copper-Nickel Cu-Ni	+ Blue – Red Jacket- Brown	+ Red – Brown Jacket- Brown	+ White – Blue Jacket- Blue	+ Red – White Jacket- Brown	+ Yellow – Blue Jacket- Blue	– 328 to 662°F – 200 to 350°C	1.0°C or 0.75% Above 0°C 1.0°C or 1.5% Below 0°C 0.5°C or 0.4%	Mild Oxidizing, Reducing Vacuum or Inert. Good Where Moisture is Present Low Temperature and Cryogenic Applications
E	Chromel Nickel-Chromium Ni-Cr	Constantan Copper-Nickel Cu-Ni	+ Purple – Red Jacket- Brown	+ Red – Green Jacket- Black	+ Brown – Blue Jacket- Brown	+ Red – White Jacket- Purple	+ Yellow – Purple Jacket- Purple	– 328 to 1652°F – 200 to 900°C	1.7°C or 0.5% Above 0°C 1.7°C or 1.0% Below 0°C 1.0°C or 0.4%	Oxidizing or Inert Limited Use in Vacuum or Reducing Highest EMF Change per Degree

Table 4-21. Temperature Function Modifiers

Item	Description
°C	Temperature in degrees Celsius.
°K	Temperature in degrees Kelvin.
°F	Temperature in degrees Fahrenheit.

Figure 4-4 shows the front and rear panel input connections used to measure temperature. Table 4-22 lists the input specifications for the temperature function.

Table 4-22. Input Specifications

Item	Description
Measurement Module	50-1 or 50-2.
Input Connections	Dual banana jack or multiplexer 50-20.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7. Thermocouple can be connected for both single ended or differential inputs, but differential connections are recommended. Remember to set the multiplexer's switch for Temp En (temperature enable). Each channel list must include at least one cold junction temperature measurement for each module used. The cold junction measurement can be a channel that contains a thermocouple.

4.5.2.6 Ohms (Resistance)

The Model 52 measures resistance using either the two-wire or four-wire technique. Resistances over 32MΩ are measured by the Model 52 which places a known internal resistance in parallel with the measured resistance, then the Model 52 calculates the value of the external resistor. The following steps illustrate the set up of the Model 52 to measure resistance.

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the **Func** key to call the function menu, and select "OHMS".
5. Press the **Range** key to call the range menu, and select the desired range. Ohms has two sets of range menus. Tables 4-23 and 4-24 list the ranges.
6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the **Mods** key to call the function modifier menu. Function modifiers alter how readings are taken and how the Model 52 responds to the reading. Function modifiers are described in paragraph 4.5.5.

Table 4-23. 30Ω to 30MΩ Ranges

Item	Range	Maximum Resolution	Output Current
30Ω	1mΩ to 32Ω	1mΩ	1mA
300Ω	10mΩ to 320Ω	10mΩ	1mA
3kΩ	100mΩ to 3.2kΩ	100mΩ	1mA
30kΩ	1Ω to 32kΩ	1Ω	100μA
300kΩ	10Ω to 320kΩ	10Ω	10μA
3MΩ	100Ω to 3.2MΩ	100Ω	1μA
30MΩ	1kΩ to 32MΩ	1kΩ	0.1μA
AUTO	(Autorange) automatically ranges up to the next higher range at 32Ω, 320Ω, 3.2kΩ, 32kΩ, 320kΩ, and 3.2MΩ and ranges down to the next lower range at 3.0MΩ, 300kΩ, 30kΩ, 3kΩ, 300Ω, and 30Ω.		

Table 4-24. 300MΩ to 3000MΩ Ranges

Item	Range	Maximum Resolution	Output Current
300MΩ	30MΩ to 100MΩ	10kΩ	100nA
	100MΩ to 320MΩ	100kΩ	100nA
3000MΩ	300MΩ to 1000MΩ	1MΩ	100nA
	1000MΩ to 3200MΩ	10MΩ	100nA
AUTOMΩ	(Autorange) automatically ranges up to the next higher range at 320MΩ and ranges down to the next lower range at 300MΩ.		

Figure 4-5 shows the front and rear panel input connections used to measure temperature. Table 4-25 lists the input specifications for the ohms function.

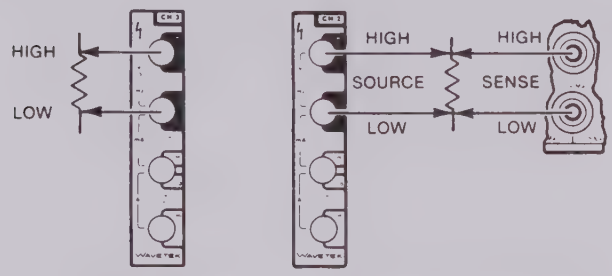


Figure 4-5. Front and Rear Panel Input Connections

Table 4-25. Input Specifications

Item	Description
Measurement	50-1.
Inputs	Front (2-wire meas.), Front and rear (4-wire meas.)
Open circuit voltage	< + 10V (front panel inputs only).
Overload protection	280Vrms or ± 400V peak continuous.
Multiplexer Inputs	The multiplexer can be used to make four-wire resistance measurements. Two multiplexer modules must be used for each group of subchannels measured. Connect the multiplexers as described in paragraph 2.3.7, except one multiplexer must connect to the rear panel inputs (sense) and the other (the other multiplexer's mate) must connect to the front panel input (source). It is important to keep track of each group of four wires for each resistance.

Two-Wire Resistance Measurements

The two-wire technique is the most common method of taking resistance measurements. Two-wire measurements are fairly accurate when using short test leads and on higher resistance ranges. For two-wire resistance measurement, use the front panel inputs. When selecting the channel, designate a front panel (XFP) input.

HINT: The display modifier Δ can be used to "zero" out test lead resistances.

Four-Wire Resistance Measurements

The four-wire technique allows you to make highly accurate measurements because test lead resistances are cancelled out. This technique is useful when measuring resistance on the lower ranges. For four-wire measurements, use the front panel (source) and rear panel inputs (sense). When selecting the channel and subscript number, designate a rear panel input (X00).

4.5.2.7 Continuity

Continuity quickly verifies circuit connections. Continuity uses the same ranges, display modifiers, and function modifiers as resistance measurements. Continuity measurements sound a 1kHz tone when the reading is less than 10% of the selected resistance range (thresholds are given in tables 4-26 and 4-27). Actual resistance readings are displayed. Continuity is also graphically represented on the display by two arrowheads: →← (open circuit) and →← (closed circuit). On the continuity ranges over 300MΩ, the continuity is measured by placing a known internal resistance in parallel with an external resistance and calculating the value of the external resistance. The following steps illustrate how to set up the Model 52 to check continuity.

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the **Func** key to call the function menu, and select "CONT" (continuity).
5. Press the **Range** key to call the range menu, and select the desired range. Continuity has two sets of range menus. Tables 4-26 and 4-27 lists the ranges.
6. If needed, press the **Disp** key to call the display modifier menu (see paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the **Mods** key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading.

Table 4-26. 30Ω to 30MΩ Ranges

Item	Range	Threshold	Maximum Resolution	Output Current
30Ω	1mΩ to 32Ω	<3Ω	1mΩ	1mA
300Ω	10mΩ to 320Ω	<30Ω	10mΩ	1mA
3kΩ	100mΩ to 3.2kΩ	<300Ω	100mΩ	1mA
30kΩ	1Ω to 32kΩ	<3kΩ	1Ω	100μA
300kΩ	10Ω to 320kΩ	30kΩ	10Ω	10μA
3MΩ	100Ω to 3.2MΩ	<300kΩ	100Ω	1μA
30MΩ	1kΩ to 32MΩ	<3MΩ	1kΩ	0.1μA
AUTO	(Autorange) automatically ranges up to the next higher range at 32Ω, 320Ω, 3.2kΩ, 32kΩ, 320kΩ, and 3.2MΩ and ranges down to the next lower range at 3.0MΩ, 300kΩ, 30kΩ, 3kΩ, 300Ω, and 30Ω.			

Table 4-27. 300MΩ to 3000MΩ Ranges

Item	Range	Threshold	Maximum Resolution	Output Current
300MΩ	30MΩ to 100MΩ	<30MΩ	10kΩ	100nA
	100MΩ to 320MΩ		100kΩ	100nA
3000MΩ	300MΩ to 1000MΩ	<300MΩ	1MΩ	100nA
	1000MΩ to 3200MΩ		10MΩ	100nA
AUTOMΩ	(Autorange) automatically ranges up to the next higher range at 320MΩ and ranges down to the next lower range at 300MΩ.			

Figure 4-5 shows the front and rear panel input connections used to measure temperature. Table 4-28 lists the input specifications for the continuity function.

Table 4-28. Input Specifications

Item	Description
Measurement Module	50-1.
Inputs	Front (2-wire meas.), front and rear (4-wire meas.).
Open Circuit Voltage	< + 10V (front panel input).
Overload Protection	280Vrms or ± 400V peak continuous.

Table 4-28. Input Specifications (Continued)

Item	Description
Multiplexer Inputs	The multiplexer can be used to make four-wire continuity measurements. Two multiplexer modules must be used for each group of subchannels measured. Connect the multiplexers as described in paragraph 2.3.7, except one multiplexer must connect to the rear panel inputs (sense) and the other (the other multiplexer's mate) must connect to the front panel input (source). It is important to keep track of each group of four wires.

Two-Wire Continuity Measurements

The two-wire technique is the most common method of continuity measurements. This is a fairly accurate method when using short test leads. For two-wire measurements, use the front panel inputs. When selecting the channel, designate a front panel (X_{FP}) input.

HINT: Δ (DMM display or function modifier menu) can be used to "zeros" out test lead resistances.

Four-Wire Continuity Measurements

Four-wire continuity measurements are a less often technique for measuring continuity. This technique would give greater accuracy to the reading by cancelling out lead resistance. Also, it is helpful when making continuity measurements over long distances on the lower ranges. For four-wire continuity measurements, use the front panel (source) and rear panel (sense) inputs. When selecting the channel, designate a rear panel input (X_{00}).

4.5.2.8 DC Decibels (dBdc)

DC decibels (dBdc) convert a dc voltage reading to dBm (dB relative to 1mW), dBW (dB relative to 1W), or dBV (dB relative to 1V) equivalent using a two-wire bridging mode which means the Model 52 assumes an external reference resistance is connected. dBdc can be used, for example, when using RF probes to measure levels which must be expressed logarithmically. The dB ranges are the same as Vdc. The following steps illustrate how to set up the Model 52 to measure dc decibels.

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Pres the **Func** key to call the function menu, and select "dBdc".
5. Press the **Range** key to call the range menu, and select the desired range. Table 4-29 range lists the ranges.
6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the **Mods** key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading. The function modifier items dBm, dBw, and reference impedance and dBV are unique to the dB function as described here in the following subparagraphs.

Table 4-29. dBdc Ranges

Item	Range	Maximum Resolution
30mV	3μV to 32mV	1μV
300mV	30μV to 320mV	10μV
3V	300mV to 3.2V	100μV
30V	3V to 32V	1mV
300V	30mV to 320V	10mV
AUTO	(Autorange) automatically ranges up to the next higher range at 32.000mV, 320.00mV, 3.2000V, and 32.000V and ranges down to the next lower range at 30.00V, 3.000V, 300.0mV, and 30.00mV.	

Figure 4-4 shows the front and rear panel input connections used to measure dBdc. Table 4-30 lists the input specifications for the dc decibel function.

Table 4-30. Input Specifications

Item	Description
Measurement Module	50-1.
Coupling	DC.
Inputs	Front and rear.
Mode	Two-wire bridging mode which means the Model 52 has a impedance input and assumes the reference resistance is externally connected.
Impedance	Menu selected reference impedance.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7 for single ended or differential inputs.

dBm Measurements

Decibels relative to 1 milliwatt measurements are made by selecting dBm from the function modifier menu. dBm is the logarithmic ratio of a dc voltage relative to the voltage required to produce 1mW into 600Ω. Use the ▲ ▼ keys to select the reference impedance: 50Ω, 75Ω, 90Ω, 93Ω, 110Ω, 125Ω, 135Ω, 150Ω, 250Ω, 300Ω, 500Ω, 600Ω, 600Ωrn, 800Ω, 900Ω, 900Ωrn, 1000Ω, or 1200Ω (rn is a relative to a noise level which is 90dB below the standard reference impedance level). 600Ω is the default impedance.

dBW Measurements

Decibels relative to 1 watt measurements are made by selecting dBW from the function modifier menu. dBW is the logarithmic ratio of an dc voltage relative to the voltage required to produce 1W into the reference impedance. Use the ▲ ▼ keys to select reference impedance: 2Ω, 4Ω, 8Ω, and 16Ω. 8Ω is the default impedance.

Relative dB Measurements

Decibels relative to a chosen value measurements are the logarithmic ratio of a dc voltage relative to the voltage required to produce a chosen value. The chosen value is set by selecting ΔRDG or ΔNUM from the display modifier menu. ΔRDG uses the current reading to represent the chosen value (0.00dB). ΔNUM allows keypad entry of a chosen value to represent 0.00dB. Relative dB can be either dBm or dBW. Both Delta readings can also be made in %.

dBV Measurements

Decibels relative to 1 volt measurements are made by selecting dBm and 1000Ω from the function modifier menu. dBV measurements are the logarithmic ratio of dc voltage relative to 1V.

4.5.2.9 Frequency

The Model 52 measures frequency using a period average counting method, which gives high resolution readings and rapid update rates. The following steps illustrate how to set up the Model 52 to measure frequency.

1. Press Power to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragrah 4.5.1).
4. Press the Func key to call the function menu, and select "FREQ" (frequency).
5. Press the Range key to call the range menu, and select the desired range. Frequency has two sets of range menus. Table 4-31 lists the ranges.
6. If needed, press the Disp key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the Mods key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading. The function modifier AC/DC allows selection of input coupling (ac or dc). SENSIT allows selection of the input sensitivity; each input coupling has its own sensitivity menus (dc sensitivity: table 4-32; ac sensitivity: table 4-33).

Table 4-31. Frequency Ranges

Range	Maximum Frequency	Maximum Resolution
10Hz	10Hz	0.000001Hz
100Hz	100Hz	0.00001Hz
1kHz	1kHz	0.0001Hz
10kHz	10kHz	0.001Hz
100kHz	100kHz	0.01Hz
1MHz	1MHz	0.1Hz to 300kHz
4 + MHz	>4MHz	1Hz to 1MHz
X10	Reading scaled by X10	For use with Pre-scalers.
X100	Reading scaled by X100	
X1000	Reading scaled by X1000	
AUTO	(Autorange) automatically ranges to the next higher range at 10Hz, 100Hz, 1kHz, 10kHz, 100kHz, and 1MHz and ranges the next lower range at 980kHz, 98kHz, 9.8kHz, 980 Hz and 98Hz.	

Table 4-32. DC Coupled Input Sensitivity

Sensitivity	Upper Threshold	Lower Threshold	Maximum Input
TTL	+ 2V	+ 0.8V	± 8Vpeak
CMOS5	+ 3.5V	+ 1.5V	± 8Vpeak
CMOS12	+ 8V	+ 4V	± 400Vpeak
± 40mV	+ 40mV	− 40mV	± 8Vpeak
± 0.4V	+ 400mV	− 400mV	± 8Vpeak
+ 80V	+ 80V	+ 40V	± 400Vpeak

Table 4-33. AC Coupled Input Sensitivity

Sensitivity (rms)	Trigger Level (peak)	Maximum Input
3mV	± 4mV	50mVrms
30mV	± 40mV	500mVrms
300mV	± 400mV	5Vrms
3V	± 4V	50Vrms
30V	± 40V	320Vrms

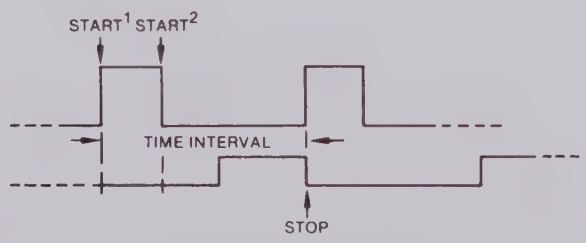
Figure 4-4 shows the front and rear panel input connections used to measure frequency. Table 4-34 lists the input specifications for the frequency.

Table 4-34. Input Specifications

Item	Description
Measurement Module	50-1.
Coupling	AC or DC, see function modifiers.
Inputs	Front and rear.
Impedance	1MΩ shunted by less than 50pF.
Maximum Input	See function modifiers.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7 for single ended or differential inputs.

4.5.2.10 Time Interval/Time Interval One Shot

The Model 52 measures both recurring and single time intervals. Time interval measures the time between a front panel trigger and an external trigger input (as shown in figure 4-6). External trigger requires an optional Digital I/O card (Optional 50-14; paragraph 2.3.9). The following steps illustrate how to set up the Model 52 to measure time interval.



1. START ON POSITIVE EDGE.
2. START ON NEGATIVE EDGE.

Figure 4-6. Time Interval

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1). The channel number which starts time interval is also the external trigger number that stops the time interval. For example, if channel 1 starts the time interval then EXT TRIG 1 must be used to stop time interval.
4. Press the **Func** key to call the function menu, and select "T-INT" (time interval).
5. Press the **Range** key to call the range menu, and select the desired range. Table 4-35 lists the ranges.
6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the **Mods** key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading. The function SENSIT allows selection of the input sensitivity; each input coupling has its own sensitivity menus (dc sensitivity: table 4-36; ac sensitivity: table 4-37). AC/DC allows selection of input coupling (ac or dc) and triggering edge (table 4-37). TRIG sets the time the unit will wait for a time interval input trigger (table 4-38).

Table 4-35. Time Interval Ranges

Range	Maximum Interval	Maximum Resolution
100ms	100 ms	1μs
1000ms	1000 ms	1μs
10s	10s	1μs
100s	100s	10μs
360s	360s	100μs
AUTO	(Autorange) automatically ranges the next higher range at 100ms, 1000ms, 10s, and 100s and ranges the next lower range at 98s, 9.8s, 980ms, and 98ms.	

Table 4-36. DC Coupled Input Sensitivity

Sensitivity	Upper Threshold	Lower Threshold	Maximum Input
TTL	+ 2V	+ 0.8V	± 8Vpeak
CMOS5	+ 3.5V	+ 1.5V	± 8Vpeak
CMOS12	+ 8V	+ 4V	± 400Vpeak
± 40mV	+ 40mV	− 40mV	± 8Vpeak
± 0.4V	+ 400mV	− 400mV	± 8Vpeak
+ 80V	+ 80V	+ 40V	± 400Vpeak

Table 4-37. AC Coupled Input Sensitivity

Sensitivity (rms)	Trigger Level (peak)	Maximum Input
3mV	± 4mV	50mVrms
30mV	± 40mV	500mVrms
300mV	± 400mV	5Vrms
3V	± 4V	50Vrms
30V	± 40V	320Vrms

Table 4-38. Time Interval Coupling

Item	Description
AC	AC coupled input.
DC	DC coupled input.
POSITIVE EDGE	Time interval triggers on the positive edge.
NEGATIVE EDGE	Time interval triggers on the negative edge.

Table 4-39. Time Interval Triggering

Item	Description
INDEF	Waits an indefinate amount of time for a trigger input.
20s	Waits 20s for a trigger input.
2s	Waits 2s for a trigger input.
200ms	Waits 200ms for a trigger input.

Figure 4-7 shows the front and rear panel input connections used to measure time interval. Table 4-40 lists the input specifications for the time interval.

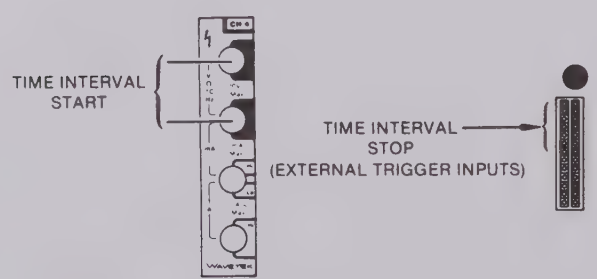


Figure 4-7. Front and Rear Panel Input Connections

Table 4-40. Input Specifications

Item	Description
Measurement Module	50-1.
Coupling	AC or DC; see function modifiers.
Impedance	1MΩ shunted by less than 50pF.
Maximum Input Multiplexer Inputs	See tables 4-36 and 4-37. Connect the multiplexer as described in paragraph 2.3.7 for single ended or differential inputs.
Digital I/O	50-14.
Trigger Input	CMOS 5V, pulled up by 100Ω. If open circuit, a logic HI is assured at input. EXT TRIG 1-PIN 10 EXT TRIG 2-PIN 11 EXT TRIG 3-PIN 12 EXT TRIG 4-PIN 13
Coupling	DC.
Triggering	Negative going edge.

Time Interval One Shot

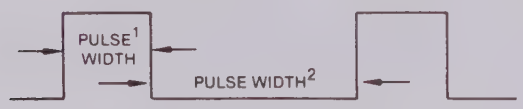
Time Interval One Shot (T-INT..ISHOT) captures a single time interval pulse. The Model 52 is set up the same as time interval except, select the function T-INT ... 1SHOT. The ranges, display modifiers, function modifiers, and inputs are the same as for standard time interval.

Once the time interval one shot is measured, the Model 52 must be reset before the next time interval one shot can be measured.

DMM mode: Press ± • to reset the one shot.
Channel List mode: Advancing to the next channel entry in the list resets the one shot.

4.5.2.11 Pulse Width/Pulse Width One Shot

The Model 52 measures both recurring and one shot pulse widths. Pulse width is the time measurement between the leading edge and the trailing edge of the input signal as shown in figure 4-8. The following steps illustrate how to set up the Model 52 to measure a pulse width.



1. Trigger on positive edge.
2. Trigger on negative edge.

Figure 4-8. Pulse Width

1. Press **Power** to turn the Model 52 on.

2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).

3. Enter the channel number (paragraph 4.5.1).

4. Press the **Func** key to call the function menu, and select "P-WTH" (pulse width).

5. Press the **Range** key to call the range menu, and select the desired range. Table 4-41 lists the ranges.

6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.

7. If needed, press the **Mods** key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading. The function modifier SENSIT allows selection of the input sensitivity; each input coupling has its own sensitivity menus (dc sensitivity: table 4-42; ac sensitivity: table 4-43). AC/DC allows selection of input coupling (ac or dc) and triggering edge (table 4-43). TRIG sets the time the unit will wait for a time interval input trigger (table 4-45).

Table 4-41. Pulse Width Ranges

Range	Maximum Width	Maximum Resolution
100ms	100 ms	1μs
1000ms	1000 ms	1μs
10s	10s	1μs
100s	100s	10μs
360s	360s	100μs
AUTO	(Autorange) automatically ranges the next higher range at 100ms, 1000ms, 10s, and 100s and ranges the next lower range at 98s, 9.8s, 980ms, and 98ms.	

Table 4-42. DC Coupled Input Sensitivity

Sensitivity	Upper Threshold	Lower Threshold	Maximum Input
TTL	+2V	+0.8V	±8Vpeak
CMOS5	+3.5V	+1.5V	±8Vpeak
CMOS12	+8V	+4V	±400Vpeak
±40mV	+40mV	−40mV	±8Vpeak
±0.4V	+400mV	−400mV	±8Vpeak
+80V	+80V	+40V	±400Vpeak

Table 4-43. AC Coupled Input Sensitivity

Sensitivity	Trigger Level	Maximum Input
3mV	±4mV	50mVrms
30mV	±40mV	500mVrms
300mV	±400mV	5Vrms
3V	±4V	50Vrms
30V	±40V	320Vrms

Table 4-44. Pulse Width Couplings

Item	Description
AC	AC coupled input.
DC	DC coupled input.
POSITIVE EDGE	Time interval triggers on the positive edge.
NEGATIVE EDGE	Time interval triggers on the negative edge.

Table 4-45. Pulse Width Triggering

Item	Description
INDEF	Waits an indefinite amount of time for a trigger input.
20s	Waits 20s for a trigger input.
2s	Waits 2s for a trigger input.
200ms	Waits 200ms for a trigger input.

Figure 4-4 in shows the front and rear panel input connections used tomeasure pulse width. Table 4-46 lists the input specifications for the time interval.

Table 4-46. Input Specifications

Item	Description
Measurement Module	Option 50-1.
Coupling	AC or DC, see function modifiers.
Impedance	1MΩ shunted by less than 50pF.
Inputs	See tables 42 and 43.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7 for single ended or differential inputs.

Pulse Width One Shot

Pulse Width One Shot (P-WTH..1SHOT) captures a single time interval pulse. The Model 52 is set up the same as time interval except, select the function P-WTH ... 1SHOT. The ranges, display modifiers, function modifiers, and inputs are the same as for standard time interval.

Once the pulse width one shot is measured, the Model 52 must be reset before the next pulse width one shot can be measured.

DMM mode: Press [± •] to reset the one shot.
Channel List mode: Advancing to the next channel list resets the one shot.

4.5.2.12 Diode Check

The Model 52 measures a diode's forward biased junction voltage using any of five source currents. The following steps illustrate how to set up the Model 52 to check diodes.

1. Press [Power] to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the [Func] key to call the function menu, and select " I-CHK" (diode check).
5. Press the [Range] key to call the range menu, and select the desired range. Table 4-47 lists the ranges for diode check.
6. If needed, press the [Disp] key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the [Mods] key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading.

Table 4-47. Diode Check Ranges

Range	Source Current
1mA	1mA source current
100μA	100μA source curren
10μA	10μA source current
1μA	1μA source current
100nA	100nA source current

Figure 4-9 in shows the front and rear panel input connections used to measure. Table 4-48 lists the input specifications for diode forward bias.

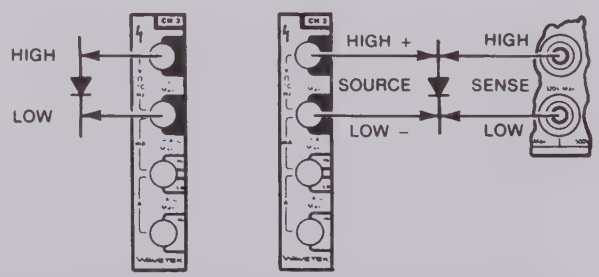


Figure 4-9. Front and Rear Panel Input Connections

Table 4-48. Input Specifications

Item	Description
Measurement Voltage Range	50-1. 0 to 3.2Vdc.
Inputs	Front and rear.
Multiplexer Inputs	The multiplexer can be used to make four-wire diode checks. Two multiplexer modules must be used for each group of subchannels measured. Connect the multiplexers as described in paragraph 2.3.7, except one multiplexer must connect to the rear panel inputs (sense) and the other (the other multiplexer's mate) must connect to the front panel input (source). It is important to keep track of each group of four wires.

Two-Wire Diode Checks

Two-wire diode checks can be made using the front panel inputs. When selecting the channel, designate a front panel (XFP) input.

Four-Wire Diode Checks

Four-wire diode checks can be made using the front panel (source) and rear panel inputs (sense). When connecting the diode to the input connectors, you must use the same channel number for both the front and rear connector (for example, channel 3 is used in figure 4-9 – Four-Wire Measurement). Enter only the channel number for the rear panel inputs (X00).

Multiplexed Diode Checks

Multiplexed diode checks can be made using two Option 50-20 multiplexer modules using the front panel (source) connectors and the rear panel connectors (sense). For details on multiplexer channel numbers, see paragraph 4.5.1.1, Multipexed Inputs.

4.5.2.13 Period

The Model 52 can make period measurements using period averaging techniques for high accuracy. Periods (4 to 262144) averaged depends on the range selected. Period is the time of one cycle of a waveform as shown in figure 4-10. The following steps illustrate how to set up the Model 52 to measure period.

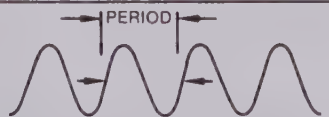


Figure 4-10. Period Waveform

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the **Func** key to call the function menu, and select "PERIOD".
5. Press the **Range** key to call the range menu, and select the desired range. Table 4-49 lists the ranges.
6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the **Mods** key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading. The function modifier SENSIT allows selection of the input sensitivity; each input coupling has its own sensitivity menus (dc sensitivity: table 4-50; ac sensitivity: table 4-51). AC/DC allows selection of input coupling (ac or dc) and triggering edge (table 4-52).

Table 4-49. Period Ranges

Range	Maximum Period	Maximum Resolution
100µs	100µs	10ps
1000µs	1000µs	100ps
10ms	10ms	1ns
100ms	100ms	10ns
1000ms	1000ms	100ns
AUTO	(Autorange) automatically ranges up to the next higher range at 100µs, 1000µs, 10ms, and 100ms and ranges down to the next lower range at 98ms, 9.8ms, 980µs, and 98µs.	

Table 4-50. DC Coupled Input Sensitivity

Sensitivity	Upper Threshold	Lower Threshold	Maximum Input
TTL	+ 2V	+ 0.8V	± 8Vpeak
CMOS5	+ 3.5V	+ 1.5V	± 8Vpeak
CMOS12	+ 8V	+ 4V	± 400Vpeak
± 40mV	+ 40mV	– 40mV	± 8Vpeak
± 0.4V	+ 400mV	– 400mV	± 8Vpeak
+ 80V	+ 80V	+ 40V	± 400Vpeak

Table 4-51. AC Coupled Input Sensitivity

Sensitivity (rms)	Trigger Level (peak)	Maximum Input
3mV	± 4mV	50mVrms
30mV	± 40mV	500mVrms
300mV	± 400mV	5Vrms
3V	± 4V	50Vrms
30V	± 40V	320Vrms

Table 4-52. Period Coupling

Item	Description
AC	AC coupled input.
DC	DC coupled input.
RISING EDGE	Period starts on the rising edge (low to high).
FALLING EDGE	Period starts on the falling edge (high to low).

Figure 4-4 shows the front and rear panel input connections used to measure period. Table 4-53 lists the input specifications for the period.

Table 4-53. Input Specifications

Item	Description
Measurement Module	50-1.
Coupling	AC or DC.
Inputs	Front and rear.
Impedance	1MΩ shunted by less than 50pF.
Maximum Input	See tables 4-50 and 4-51.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7 for single ended or differential inputs.

4.5.2.14 Events

The Model 52 can totalize (0 to 9,999,999 counts) events. The following steps illustrate how to set the Model 52 to count events.

1. Press Power to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the Func key to call the function menu, and select "EVENTS".
5. There are no range menus for the events function.
6. If needed, press the Disp key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed. The display modifier RES has no use except to select bar graphs (for details on bar graphs, see paragraphs 3.2.1, item 2, and 4.5.4.2, Bar graphs). When the bar graph exceeds the event counts, the screen displays "OVRRNG". The digits resolution is always fixed at 1 count.
7. If needed, press the Mods key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading. The function modifier SENSIT allows selection of the input sensitivity; each input coupling has its own sensitivity menus (dc sensitivity: table 4-54; ac sensitivity: table 4-55). AC/DC allows selection of input coupling (ac or dc) and triggering edge (table 4-56).

Table 4-54. DC Coupled Input Sensitivity

Sensitivity	Upper Threshold	Lower Threshold	Maximum Input
TTL	+ 2V	+ 0.8V	± 8Vpeak
CMOS5	+ 3.5V	+ 1.5V	± 8Vpeak
CMOS12	+ 8V	+ 4V	± 400Vpeak
± 40mV	+ 40mV	− 40mV	± 8Vpeak
± 0.4V	+ 400mV	− 400mV	± 8Vpeak
+ 80V	+ 80V	+ 40V	± 400Vpeak

Table 4-55. AC Coupled Input Sensitivity

Sensitivity	Trigger Level	Maximum Input
3mV	± 4mV	50mVrms
30mV	± 40mV	500mVrms
300mV	± 400mV	5Vrms
3V	± 4V	50Vrms
30V	± 40V	320Vrms

Table 4-56. Coupling

Item	Description
AC	AC coupled input.
DC	DC coupled input.
RISING EDGE	Period starts on the rising edge (low to high).
FALLING EDGE	Period starts on the falling edge (high to low).

Figure 4-4 shows the front and rear panel input connections used to count events. Table 4-57 lists the input specifications for the events function.

Table 4-57. Input Specifications

Item	Description
Measurement Module	50-1.
Coupling	AC or DC.
Inputs	Front and rear.
Impedance	1MΩ shunted by less than 50pF.
Maximum Input	See tables 4-54 and 4-55.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7 for single ended or differential inputs.

4.5.2.15 Logic

The Model 52 measures logic levels. This function provides an easy check of levels and activity. The logic level is displayed as a 1 or 0. An alarm could be used to initiate an audible tone. The following steps illustrate how to set up the Model 52 to measure dc voltage.

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the **Func** key to call the function menu, and select "LOGIC".
5. There are no range menus for the logic function.
6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed. The display modifier RES has no use except to select bar graphs. For logic, the full scale bargraph displays an empty bar for 0 and a filled bar for 1.
7. If needed, press the **Mods** key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading. The function modifier items SENSIT (sensitivity), NORMAL, and INVERT are used with the logic function (see tables 4-58 and 4-59).

Table 4-58. Logic Function Modifiers

Item	Description
SENSIT	Calls the sensitivity menu: see table 4-58.
NORMAL	Selects normal logic. A "HI" input level displayed as a "1".
INVERT	Selects inverted logic. A "HI" input level displayed as a "0".

Table 4-59. Sensitivity Items

Sensitivity	Upper Threshold	Lower Threshold	Maximum Input
TTL	+2V	+0.8V	±8Vpeak
CMOS5	+3.5V	+1.5V	±8Vpeak
CMOS12	+8V	+4V	±400Vpeak
±40mV	+40mV	−40mV	±8Vpeak
±0.4V	+400mV	−400mV	±8Vpeak
+80V	+80V	+40V	±400Vpeak

Figure 4-4 shows the front and rear panel input connections used to measure logic levels. Table 4-60 lists the input specifications for the logic function.

Table 4-60. Input Specifications

Item	Description
Measurement Module	50-1.
Inputs	Front and rear.
Impedance	1MΩ shunted by less than 50pF.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7 for single ended or differential inputs.

4.5.2.16 Cold Junction Temperature

The Model 52 measures cold junction temperature. Cold junction is the reference temperature for the thermocouples used for the temperature function. Cold junction temperature may be in degrees Celsius (°C) or Fahrenheit (°F). The cold junction temperature is useful in calculating the temperature if thermocouples other than type J, K, E, and T are used. When measuring temperature with multiplexer modules, at least one cold-junction temperature measurement per multiplexer module must be included in the channel list, otherwise the Model 52 will not take any measurements. The following steps illustrate how to set up the Model 52 to measure cold junction temperature.

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the **Func** key to call the function menu, and select "CJTEMP" (cold junction temperature).
5. There is no range menu for the cold junction function.
6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the **Mods** key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading. The function modifier items °C and °F are unique to this function (table 4-61).

Table 4-61. Cold Junction Temperature Modifiers

Item	Description
°C	Cold-junction temperature displayed in degrees Celsius.
°F	Cold-junction temperature displayed in degrees Fahrenheit.

Table 4-62 lists the input specifications. No input connections are required for cold junction measurements.

Table 4-62. Input Specifications

Item	Description
Measurement Module	50-1 and 50-2.
Inputs	Front panel none required.
Multiplexer Inputs	Connect the multiplexer as described in paragraph 2.3.7.

4.5.2.17 Ampere DC

The Model 52 measures dc currents up to 10A by placing the Model 52 in series with circuit being measured. The following steps illustrate how to set up the Model 52 to measure dc amperes.

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the **Func** key to call the function menu, and select "Adc".
5. Press the **Range** key to call the range menu, and select the desired range. Table 4-63 lists the ranges for dc voltage.
6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the **Mods** key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading.

Table 4-63. DC Amperes Range

Range Description	Maximum Resolution	Maximum Burden Voltage[1]
30mA to 32 mA	100 nA	40 mV
300mA up to 320 mA	1 μA	400 mV
3A up to 3.2 mA	10 μA	150 mV
10A up to 10 A	100 μA	50 mV
mA AUTO	(mA autorange) automatically ranges up the 200 mA range at 32 mA and ranges down to the 30 mA range at 30 mA.	
A AUTO	(A autorange) automatically ranges up to the 10 A range at 3.2 A and range down to the 3 A range at 3 A.	

[1]Burden voltage is the error caused by the voltage drop across the Model 52 measuring circuit.

Figure 4-11 shows the front panel input connections used to measure dc amperes. Table 4-64 lists the input specifications for the dc ampere function.

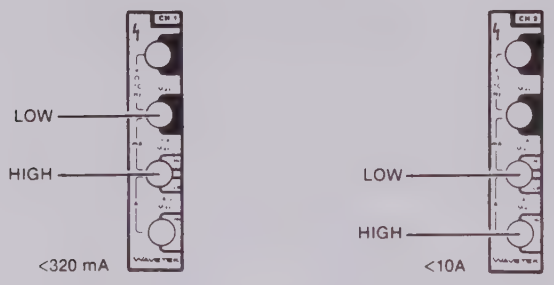


Figure 4-11. Front Panel Input Connections

Table 4-64. Input Specifications

Item	Description
Measurement Module	50-1.
Coupling	DC.
Inputs	Front panel only.
Maximum Burden Voltage	See table 4-63.
Overload	320 mA input: 1A fuse (3AG). 10 A input: Unfused, up to 30 A input for 20 sec maximum.
Multiplexer Inputs	A multiplexer can not be used to directly measure current. But, if a shunt is placed across the multiplexer's terminal points and the Model 52 setup to measure voltage, the multiplexer can be used to measure current. Hint: use the math channel or scale to calculate the current through the shunt (I = E/R).

4.5.2.18 Ampere AC

The Model 52 measures ac current (true rms, shunt dc coupled) up to 10 A by placing the Model 52 in series with the circuit being measured. The following steps illustrate how to set up the Model 52 to measure ac current.

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the **Func** key to call the function menu, and select "Aac".
5. Press the **Range** key to call the range menu, and select the desired range. Table 4-65 lists the ranges for dc voltage.
6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the **Mods** key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading.

Table 4-65. AC Amperes Range

Range Description	Maximum Resolution	Maximum Burden Voltage[1]
<32mA	100 nA	40 mV
30mA to 320 mA	1 μA	400 mV
300mA to 3.2 A	10 μA	150 mV
3A to 10 A	100 μA	500 mV
mA AUTO	(mA autorange) automatically ranges up the 200 mA range at 32 mA and ranges down to the 30 mA range at 30 mA.	
A AUTO	(A autorange) automatically ranges up to the 10 A range at 3.2 A and range down to the 3 A range at 3 A.	

[1] Burden voltage is the error caused by the voltage drop across the Model 52 measuring circuit.

Figure 4-11 shows the front panel input connections used to measure ac amperes. Table 4-66 lists the input specifications for the ac ampere function.

Table 4-66. Input Specifications

Item	Description
Measurement Module	50-1.
Coupling	DC on the shunt, only AC component measured.
Inputs	Front panel.
Maximum Burden Voltage	See table 4-65.

Table 4-66. Input Specifications (Continued)

Item	Description
Overload Protection	320 mA input: 1A fuse (3AG). 10 A input: Unfused, up to 30 A input for 20 sec maximum.
Multiplexer Inputs	A multiplexer can not be used to directly measure current. But, if a shunt is placed across the multiplexer's terminal points and the Model 52 setup to measure voltage, the multiplexer can be used to measure current. Hint: use the math channel or scale to calculate the current through the shunt (I = E/R).

4.5.2.19 Ampere AC + DC

The Model 52 can measure the ac (true rms) and dc component of an input signal by placing the Model 52 in series with the circuit being measured. The following steps illustrate how to set up the Model 52 to measure ac + dc current.

1. Press Power to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the Func key to call the function menu, and select "Aac + dc".
5. Press the Range key to call the range menu, and select the desired range. Table 4-67 lists the ranges for ac + dc current.
6. If needed, press the Disp key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the Mods key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading.

Table 4-67. AC + DC Current Ranges

Range Description	Maximum Resolution	Maximum Burden Voltage
32 mA	100 nA	40 mV
30mA to 320 mA	1 μA	400 mV
300A to 3.2 mA	10 μA	150 mV
3A up to 10 A	100 μA	500 mV

Table 4-67. DC Amperes Range (Continued)

Range Description	Maximum Resolution	Maximum Burden Voltage
mA AUTO	(mA autorange) automatically ranges up the 200 mA range at 32 mA and ranges down to the 30 mA range at 30 mA.	
A AUTO	(A autorange) automatically ranges up to the 10 A range at 3.2 A and range down to the 3 A range at 3 A.	

[1]Burden voltage is the error caused by the voltage drop across the Model 52 measuring circuit.

Figure 4-11 shows the front panel input connections used to measure ac + dc amperes. Table 4-68 lists the input specifications for the ac + dc ampere function.

Table 4-68. Input Specifications

Item	Description
Measurement Module	50-1.
Coupling	DC.
Inputs	Front panel.
Maximum Burden Voltage	See tble 4-67.
Overload Protection	320 mA input: 1A fuse (3AG). 10 A input: Unfused, up to 30 A input for 20 sec maximum.
Multiplexer Inputs	A multiplexer can not be used to directly measure current. But, if a shunt is placed across the multiplexer's terminal points and the Model 52 setup to measure voltage, the multiplexer can be used to measure current. Hint: use the math channel or scale to calculate the current through the shunt (I = E/R).

4.5.2.20 DC Watts

The Model 52 measures dc watts by taking alternate readings of current and voltage and multiplying them together. The range menu requires selection of a

voltage range and current range. Watt measurements are made using front panel inputs only. The following steps illustrate how to set up the Model 52 to measure dc watts.

1. Press **Power** to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the **Func** key to call the function menu, and select "Wdc".
5. Press the **Range** key to call the range menu, and select the desired range. Table 4-69 lists the ranges for dc wattage.
6. If needed, press the **Disp** key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the **Mods** key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading.

Table 4-69. DC Watts Ranges

Current Range	Voltage Range	Maximum Watts	Maximum Resolution (7 digit)
300 mA	30	10.24	100 μW
300 mA	300	102.4	1 mW
3 A	30	102.4	1 mW
3 A	300	1024	10 mW
10 A	30	320	10 mW
10 A	300	3200	100 mW

Figure 4-12 shows the front panel input connections used to measure dc watts. There are two types of input setups shown. One setup measures the power supplied by a source, and the other setup measures the power into a load. Table 4-70 lists the input specifications for the dc watts function.

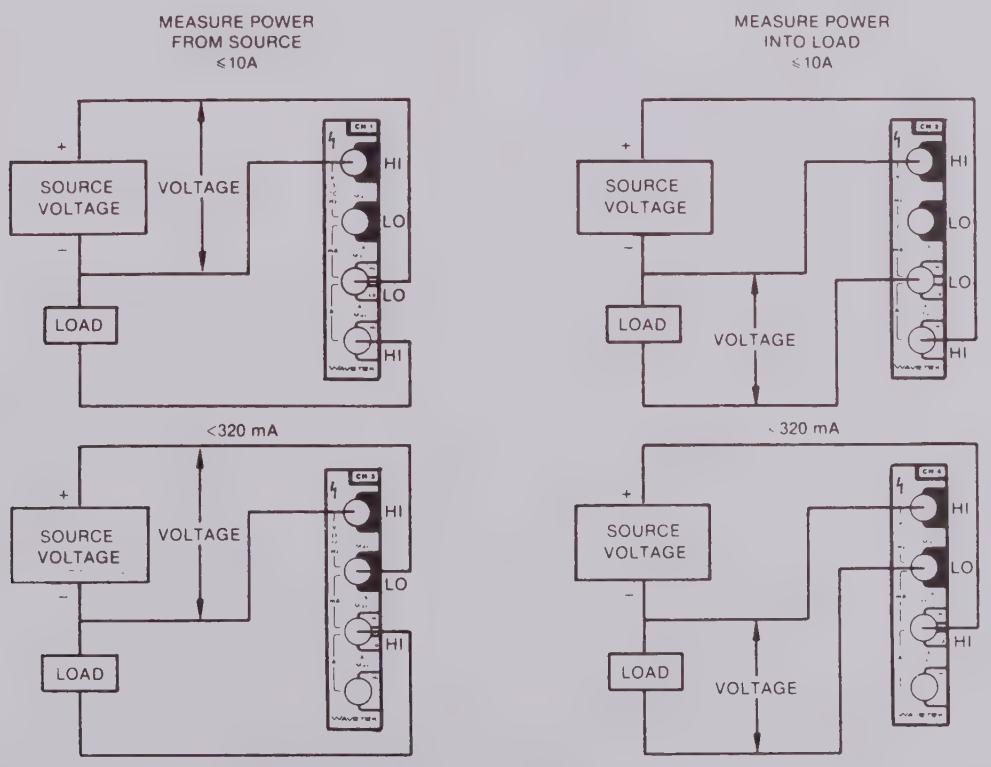


Figure 4-12. Front Panel Input Connections

Note: Connection shown places the load in the positive leg, before the load. By reversing the polarity of the voltage source the shunt will be in the low (usually ground return) leg, after the load.

Table 4-70. Input Specifications

Item	Description
Measurement Module	50-1.
Inputs	Front panel.
Multiplexer Inputs	The multiplexer can not be used to directly measure watts. However, using two multiplexers and the math channel the Model 52 can measure multiplexed power. Place a shunt (current through the load) across the terminal points of one multiplexer and set the unit to measure voltage. Measure the voltage across the load using a paralleled multiplexer. Hint: use the math channel to calculate the power.

4.5.2.21 Volt-Amperes AC

The Model 52 can measure ac volt-amperes by taking alternate readings of current and voltage and multiplying them together. Power factor is not included when making volt-ampere measurements, therefore volt-amperes ac does not measure "true" power. The range menu requires selection of a voltage range and current range. The following steps illustrate how to set up the Model 52 to measure ac volt-amperes.

1. Press Power to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the Func key to call the function menu, and select "VAac".
5. Press the Range key to call the range menu, and select the desired range. Table 4-71 lists the ranges for ac volt-amperes.
6. If needed, press the Disp key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the Mods key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading.

Table 4-71. AC Volt-Ampere Ranges

Current Range	Voltage Range	Maximum Watts	Maximum Resolution
300 mA	30	10.24	100 μVA
300 mA	300	102.4	1 mVA
3 A	30	102.4	1 mVA
3 A	300	1024	10 mVA
10 A	30	320	10 mVA
10 A	300	3200	100 mVA

Figure 4-12 shows the front panel input connections used to measure ac volt-amperes. There are two types of input set ups shown. One setup measures the apparent power supplied by a source, and the other setup measures the apparent power into a load. Table 4-72 lists the input specifications for the ac volt-ampere function.

Table 4-72. Input Specifications

Item	Description
Measurement Module	50-1.
Inputs	Front panel.
Multiplexer Inputs	The multiplexer can not be used to directly measure volt-amperes. However, using two multiplexers and the math channel the Model 52 can measure multiplexed power. Place a shunt (current through the load) across the terminal points of one multiplexer and set the unit to measure voltage. Measure the voltage across the load using a paralleled multiplexer. Hint: use the math channel to calculate volt-amperes.

4.5.2.22 Volt-Amperes AC + DC

The Model 52 can measure ac + dc volt-amperes by taking alternate readings of current and voltage and multiplying them together. The range menu requires selection of a voltage range and current range. The

following steps illustrate how to set up the Model 52 to measure ac + dc volt-amperes.

1. Press Power to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number (paragraph 4.5.1).
4. Press the Func key to call the function menu, and select "VAac + dc".
5. Press the Range key to call the range menu, and select the desired range. Table 4-73 lists the ranges.
6. If needed, press the Disp key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed.
7. If needed, press the Mods key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading.

Table 4-73. AC + DC Volt-Ampere Ranges

Current Range	Voltage Range	Maximum VA	Maximum Resolution
300 mA	30	10.24	100 μVA
300 mA	300	102.4	1 mVA
3 A	30	102.4	1 mVA
3 A	300	1024	10 mVA
10 A	30	320	10 mVA
10 A	300	3200	100 mVA

Figure 4-12 shows the front panel input connections used to measure ac + dc volt-amperes. There are two types of input set ups shown. One setup measures the apparent power supplied by a source, and the other setup measures the apparent power into a load. Table 4-74 lists the input specifications for the ac volt-ampere function.

Table 4-74. Input Specifications

Item	Description
Measurement Module	50-1.
Inputs	Front panel.

Table 4-74. Input Specifications (Continued)

Item	Description
Multiplexer Inputs	The multiplexer can not be used to directly measure volt-amperes. However, using two multiplexers and the math channel the Model 52 can measure multiplexed power. Place a shunt (current through the load) across the terminal points of one multiplexer and set the unit to measure voltage. Measure the voltage across the load using a paralleled multiplexer. Hint: use the math channel to calculate the volt-amperes.

4.5.3 Digital I/O

The Digital I/O (Input/Output) card, Option 50-14 provides input and output connections for monitor and control applications. Plus, the Digital I/O supplies a user-set proportional analog output (paragraph 4.5.5.3 TRACK) and receives the trigger input for channels 1, 2, 3, and 4. Channel numbers for the Digital I/O are 5, 6, 7, and 8. Selecting the subscript number sets up the "function" of the channel. Paragraph 2.3.8 describes the Digital I/O connector. The following steps illustrate how to set up the Model 52's digital I/O channels.

1. Press Power to turn the Model 52 on.
2. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
3. Enter the channel number and subscript (paragraph 4.5.3.1, 4.5.3.2, 4.5.3.3, and 4.5.3.4).
4. If needed, press the Disp key to call the display modifier menu (paragraph 4.5.4). Display modifiers alter the way readings are displayed. Display modifiers unique to digital I/O are described in the following paragraphs.
5. If needed, press the Mods key to call the function modifier menu (paragraph 4.5.5). Function modifiers alter how readings are taken and how the Model 52 responds to the reading. Function modifiers unique to digital I/O are described in the following paragraphs.

Note

Digital I/O channels do not have function and range menus.

4.5.3.1 Digital Input Byte

The digital input byte measures (monitors) the entire byte and displays, stores, and transmits the byte in a form set by the display modifier. To select the input byte, enter the channel number followed by the subscript 00 (X_{00}) X represents the digital channel number. The Model 52 reads the input byte at the Digital I/O connector (paragraph 2.3.8). Table 4-75 describes the display modifiers unique to an input byte. Table 4-76 describes the function modifiers unique to an input byte.

Table 4-75. Input Byte Display Modifiers

Item	Description
BIN	Digital input displayed as a binary number.
HEX	Digital input displayed as a hexa-decimal number.
OCT	Digital input displayed as an octal number or "x" if invalid octal digit.
ASCII	Digital input displayed as an ASCII (American Standard Code for Information Interchange) character or period "." if not a standard ASCII character.
BCD	Digital input displayed as a BCD (Binary Coded Decimal) number or "x" if invalid BCD digit.

Note

Undefined patterns (such as 1100 1110 in BCD) will be displayed as "x".

Table 4-76. Input Byte Function Modifier

Item	Description
NORMAL	Input displayed as received; High = 1, Low = 0.
INVERT	Input inverted; for example, the input binary number 01010101 will be displayed as 10101010.

4.5.3.2 Digital Input Bit

The digital input bit measures (monitors) a single bit and displays, stores, and transmits the byte in a form set by the display modifier. To select the input bit, enter the channel number followed by the subscript 0Y (X_{0y}: X represents the digital channel number and y represents which bit is read). The Model 52 reads the input bit at the Digital I/O connector (paragraph 2.3.8). Table 4-77 describes the display modifiers unique to input bit. Table 4-78 describes the function modifiers unique to input bit.

Table 4-77. Input Bit Display Modifiers

Item	Description
BIT	Displays the single selected bit as "1" or "0".
MASK	Display the single selected bit in its position all other positions are masked out (for example: XX1XXXXX).
BYTE	Displays the entire byte but operates only on a selected bit.

Table 4-78. Input Bit Function Modifiers

Item	Description
NORMAL	Input displayed as received.
INVERT	Input inverted; for example, a "1" will be displayed as a "0".

4.5.3.3 Digital Output Byte

The digital outut byte controls an output byte that can control, for example, combinations of relay or proram binary devices. To select the output byte, enter the channel number followed by the subscript 10 (X_{10}) X represents the digital channel number. The Model 52 writes a binary output byte to the Digital I/O connector (paragraph 2.3.8). Table 4-79 describes the display modifiers unique to an output byte. The output byte is always binary regardless of the display modifier. Table 4-80 describes the function modifiers unique to an output byte.

Setting the Byte

The initial output byte can be set, otherwise the default value is 00000000. The Func (Function) key allows entry of the output byte. For example, Func 10011100 Enter establishes 10011100 as the initial binary number. How the number is entered depends on the selected display modifier (table 4-79). The default initial setting is "0" (BIN, HEX, OCT, BCD, and DECIMAL) or "x" (all bits undefined in ASCII).

Table 4-79. Output Byte Display Modifiers

Item	Description
BIN	Digital output displayed as a binary number.

Table 4-79. Output Byte Display Modifiers (Continued)

Item	Description
HEX	Digital output displayed as a hexadecimal number.
OCT	Digital output displayed as an octal number.
ASCII	Digital output displayed as an ASCII (American Standard Code for Information Interchange) character.
BCD	Digital output displayed as a BCD (Binary Coded Decimal) number.

Table 4-80. Output Byte Function Modifier

Item	Description
INCRMT	Output byte increases 1 bit for each reading of the channel/subchannel. For example, the binary number 01010101 increments to 01010110.
CMPLMT	Output byte complements for each reading of the channel/subchannel. For example, the binary number displayed as 01010101 will be transmitted as 10101010.
DECRMT	Output byte decreases 1 bit for each reading of the channel/subchannel. For example, the binary number 01010101 decrements to 01010100.
None Selected	Output byte does not change.

4.5.3.4 Digital Output Bit

The digital output bit controls an individual output bit that can control, for example, a single relay or toggle an external device. To select the output bit, enter the channel number followed by the subscript 1Y (X_1Y: Y represents the output bit). The Model 52 writes an output bit to the Digital I/O connector (paragraph 2.3.8). Table 4-81 describes the display modifier items unique to the output bit. Table 4-82 describes the function modifier items unique to the output bit.

Setting the Bit

Func key allows entry of an output bit. For example, Func 1 Enter establishes 1 as the initial binary number. The default, initial setting is "0".

Table 4-81. Output Bit Display Modifier

Item	Description
BIT	Displays the single selected bit as "1" or "0".
MASK	Displays the single selected bit in its position. All other positions are masked ("X") out (for example: XX1XXXXX).
BYTE	Displays the entire output byte.

Table 4-82. Output Bit Display Modifier

Item	Description
INCRMT, CMPLMT, DECRMT	The output bit changes state each time the measurement is made.
None Selected	Output bit does not change.

4.5.4 Display Modifiers

The display modifiers affect how the readings are displayed, stored, or transmitted. Display modifiers are set up after you have selected the mode (paragraphs 4.5 and 4.6), channel number (paragraph 4.5.1), function (paragraph 4.5.2), and range (paragraph 4.5.2). All the display modifiers described in this paragraph are common to all functions. Those display modifiers unique to a function are described with that function.

4.5.4.1 Scale

Scale allows the Model 52 to automatically adjust the measurement reading by your preset math formula. The scale display modifier applies the math channel formula (paragraph 4.3.7) to whatever channel reading the formula is assigned to.

Creating The Scale Formula

A Scale math channel is entered, edited, and deleted exactly the same as the regular math channel. All conventions and operators for scaling are the same as the conventional math channel, except the variable "X", which is the reading to be scaled by the math channel formula (paragraph 4.3.7). Example 4-4 shows how to enter a formula to read a 4 to 20 mA transducer to display pressure.

Example 4-4. Creating Pressure Transducer Scaling

This example creates a math channel formula to scale an 4 to 20 mA current input from a 0 to 10 psi pressure transducer connected to the front panel input of channel 1 and displays the reading directly in pounds per square inch.

Step	Action	Display
1	From the Main Menu, select MATH.	<MATH <ALARMS <TRACKING <UNIT STATUS
2	Press 1 and Enter to enter the channel subscript number.	MATH NUMBER LABEL (1-99) " " 01
3	Use the Func, ▲ ▼, and number keys to enter the operators and constants for the scale formula.	D01=(X-0.004)* 625
4	Press Enter to accept the formula.	LABEL? "MATH" ----
5	Use the ▲ ▼ and Enter keys to enter the label "PSI".	LABEL? "MATH" PSI_
6	Press Enter to accept the label.	

Using the Scale formula

Once the scaling formula is created, it can be used to alter a reading. Example 4-5 shows how to use the math channel formula created in example 4-4.

Example 4-5. Using a Scale Formula

Step	Action	Display
1	Select DMM.	<DMM <CHANNEL LIST <PROGRAM <RECALL DATA

Example 4-5. Using a Scale Formula (Continued)

Step	Action	Display
2	Press Chan, 1, and Enter.	0.0056 1FP Vdc <▲ ▲%>
3	Press Func twice and select Adc.	1FP 0.0056 Vdc <Adc Wdc> <Aac VAac+dc> <Aac+dc VAac>
4	Press Range and select 30mA.	1FP 4.180 mAdc <mA -AUTO A> <30mA 3A> <300mA 10A>
5	Press Disp.	1FP 4.180 mAdc <SCALE RES> <MIN AVG> <MAX DELTA>
6.	Select SCALE.	1FP 4.180 mAdc SCALE USING CH# 0xx (1-99) --
7	Press 1, the math channel subscript from example 4-4. Press Enter twice to return to the DMM display. The transducer connected to the front panel input of channel 1 produces a 4 to 20 mA output current. The math channel scales the measurement and the screen displays the measurement directly in psi.	0.1125 1FP PSI <▲ ▲%>

4.5.4.2 Resolution

This item allows the user to change the measurements resolution. There are two reasons to changing resolution:

1. Elimination of fluctuating least significant digits.
2. Faster reading rate.

Standard Measurement Resolution

The three resolutions described in table 4-83 are used for all functions except frequency related functions which are covered under frequency resolution.

Table 4-83. Standard Resolution

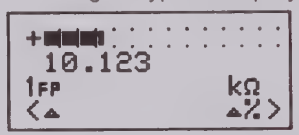
Resolution	Description
320	Displays the reading in 2½ digits of display resolution. Update rate: 16 reading per second.
3200	Displays the reading in 3½ digits of display resolution. Update rate: 16 readings per second.

Table 4-83. Standard Resolution (Continued)

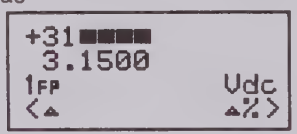
Resolution	Description
32000	Displays the reading in 4½ digits of display resolution. Update rate: 5 readings per second.
– – –	Full Scale Bar Graph.
32 – –	High Resolution Bar Graph.

Bar graphs are the analog representations of a measurement. The Model 52 uses two types of bar graphs: full scale and high resolution.

Full scale bar graphs represent 100% of the selected range. Bar graphs are primarily for relative measurements. The channel list type display shows the full scale bar graph by itself. When a reading exceeds the range the display returns to the standard digital display. The DMM type display shows both the bar graph and the actual reading. A typical display is:



The high resolution bar graph displays the two most significant digits as numbers and the remaining digits as a bar graph. Bar graphs are primarily relative measurements. For example: a reading of 3.15V would be displayed as



(note there is no decimal point) A reading of 0.35V on the same range would be displayed as

Note: Watts and VA measurements employ the 999999 display resolution menu.

Frequency Type Resolution

The five frequency resolution items are described in table 4-84. Reading rate is ≤6 digits per 0.3 seconds.

Table 4-84. Frequency Resolution

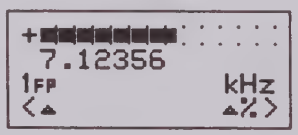
Resolution	Description
99999	Displays the reading in five digits of resolution.
999999	Displays the reading in six digits of resolution.

Table 4-84. Frequency Resolution (Continued)

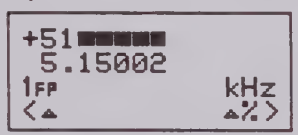
Resolution	Description
9999999	Displays the reading in seven digits of resolution.
– – –	Full Scale Bar Graph.
99 – –	High Resolution Bar Graph.

Frequency bar graphs are the analog representations of a measurement. The Model 52 uses two types of bar graphs: full scale and high resolution.

Full scale bar graphs represent 100% of the selected range. Bar graphs are primarily for relative measurements. The channel list type display shows the full scale bar graph by itself. When a reading exceed the range the display returns to the standard digital display. The DMM type display shows both the bar graph and the actual reading. A typical display is:



The high resolution bar graph displays the two most significant digits as numbers and the remaining digits as a bar graph. Bar graphs are primarily for relative measurements. For example: a reading of 5.15 kHz would be displayed as



(note there is no decimal point) A reading of 0.51 kHz on the same range would be displayed as

4.5.4.3 Average

This selection sums the readings set by the user and divides by the number of readings. The display and memory are updated only after the readings are averaged. Between 1 and 255 readings can be averaged. The normal display averages 5 readings. An averaged reading of 1 overrides the normal display averaging. The default stored or transmitted average reading is "0". In other words, stored and transmitted readings not normally averaged, unless averge is included with the channel measurement. The update rate depends on the number of readings averaged and the resolution selected. When a DMM type display is used, "Av" is

displayed on the screen. Table 4-85 shows the update rate versus resolution along with an example of a 10 reading average time.

Table 4-85. Average Reading Rates

Resolution	Reading Rate	10 Count Example
Nonfrequency		
32000 (4½ digits)	6/sec	2 sec update
3200 (3½ digits)	16/sec	0.63 sec update
320 (2½ digits)	16/sec	0.63 sec update
Frequency		
9999999 (7 digits)	1/13 sec	130 sec update
999999 (6 digits)	10/13 sec	13 sec update
99999 (5 digits)	100/13 sec	1.3 sec update

Actual reading rates vary slightly depending on the mode. The 4½ digit A/D modes vary from 4 to 6 readings per second.

To average a reading,

1. Set up the channel to be measured.
2. Press **Disp** to call the display modifier menu as shown below.

```
1FP 1.5746  Vdc
<SCALE     RES>
<MIN       AVG>
<MAX     DELTA>
```

3. Select AVG to allow you to enter the number of readings to be averaged. The display is:

```
1FP 1.5746  Vdc
AVERAGE n RDGS
   (1-255)
      ---
```

4. Enter the number of readings to be averaged (1 to 255).
5. Press **Enter** twice to return to the display screen.

4.5.4.4 Delta

This item displays the measurement relative to a value. The value can be a user entered value (ΔNUM) or a reading at the time delta (Δ) was selected. Table 4-86 describes the delta menu items.

To select DELTA,

1. Set up the channel to be measured.
2. Press **Disp** to call the display modifier menu as shown below.

```
1FP 1.5746  Vdc
<SCALE     RES>
<MIN       AVG▶
<MAX     DELTA>
```

3. Select DELTA to call the delta menu as shown below.

```
1FP 1.5746  Vdc
<▲RDG      ▲NUM>
<▲%RDG     ▲%NUM>
RL
```

To enter a relative number (REL),

1. Press **Clear**.
2. Enter the number using the numeric keys or the ▲ ▼ cursor keys and **•±** key for decimal points. The unit of measure is the same as the selected range.

The new relative reading (REL) is displayed at the bottom of the menu screen.

Table 4-86. Delta

Item	Description
ΔRDG	Displays the deviation in the unit of measure relative to the reading at the time the key was pressed. The relative reading (RL) is displayed at the bottom of this screen.
Δ%RDG	Displays the deviation in percent relative to the reading at the time the key was pressed. The relative reading (RL) is displayed at the bottom of the menu screen. Percent (%) resolution defaults to 0.01% in all functions. When the percentage exceeds 999.99% the resolution ranges to 0.1% because the Model 52 will display as many digits of resolution as possible. Exceeding 999.99% at 0.01% resolution would exceed the space on the display. And on all function except counter function, the resolution can range to 1%. However, on counter percentages the percentage starts at 0.001% and ranges to 0.01% and 0.1%.
ΔNUM	Displays the deviation relative to a user entered number which is displayed as RL at the bottom of the screen.
Δ%NUM	Displays the deviation in percent relative to a user entered number which is displayed as RL at the bottom of the screen.

4.5.5 Function Modifiers (Mods)

The function modifier (Mods) alters how the data is taken and how the unit responds to the data. Function modifiers are set up after you have selected the mode (paragraphs 4.5 and 4.6), channel number (paragraph 4.5.1), function (paragraph 4.5.2), and range (paragraph 4.5.2). All the function modifiers described in this paragraph are common to all functions. Those function modifiers unique to a function are described with that function.

A typical function modifier (Mods) menu is for Function: Vdc:

```
1FP 1.5746  Vdc
<DELAY   CAL 0>
<ALARM     CAL>
<TRACK Z=10MΩ>
```

Other function modifier menus are similar, that is, most menus have DELAY, ALARM, and TRACK items. Also, some menus have CAL or CAL 0 selections.

4.5.5.1 Delay

Delay postpones the channel measurement. Delays can be made in 0.1 second increments up to 25.4 seconds. Delays are useful in taking measurements of circuits that require settling time.

For channels 1 through 4, every channel measurement in a channel list can be delayed as desired. However, for channels 0 and 5 through 9, a maximum of 32 channel measurements per channel list can be delayed.

To enter a delay,

1. Press Mods to call the function modifier menu as shown below.

```
1FP 1.5746  Vdc
<DELAY   CAL 0>
<ALARM     CAL>
<TRACK Z=10MΩ>
```

2. Select DELAY to allow you to enter the delay time. The display follows.

```
DELAY READING
  (254 MAX)
    x .1s
      ---
```

3. Use the numeric keys enter the delay time or the ▲ ▼ cursor keys to step through numbers (press Enter to accept the number).

   Decimal points do not need to be entered. The Model 52 assumes the least significant digit to be 1/10th of a second. If only one digit is entered, it represents a 1/10th of a second. For example, entering 1 and 8 will delay the reading by 1.8 seconds.

4.5.5.2 Alarm

Alarms can, for example:

- Change data logging parameters by running a program or channel list that could monitor inputs or change control conditions.
- Control by sending a bit or byte pattern to digital output.
- Store out of limit conditions.
- Transmit out of limit conditions.
- Transmit warning to remote operator.
- Alert a local operator with a tone.

The alarm, as used in the Model 52, is a setpoint (threshold) or "window" set up, coupled with some response-action that takes place if the measurement is outside or inside this limit. An Alarm, when used with a channel reading, monitors the reading. When the reading meets the setpoint set by the alarm, the alarm responds. The alarm response can generate a tone, change a display (by placing a black background on the units of measure), store data, run a program, and initiate a digital output response. A single alarm number can be attached to one or more channel numbers.

Note

When several channel measurements in a channel list use the same latched alarm, a true condition on and of the channel measurements will cause the black background display to appear on all the channel measurements.

Creating Alarms

There are five steps to creating an alarm:

1. Select ALARMS from the Main Menu.

```
<MATH
<ALARMS
<TRACKING
<UNIT STATUS
```

2. Enter the Alarm number.

```
ALARM NUMBER?
   (1-31)
     --
```

There are 31 possible alarm numbers (1 to 31). Existing alarm numbers can be reviewed by using the ▲ ▼ cursor keys to step through the numbers.

3. Select the Alarm trigger conditions (table 4-87). (This display shows "A01", alarm number 1.)

```
A01   ENABLED▶
<X≤T1 LATCHED>
◀X≥T1 T1≤X≤T2>
<X≤T1 OR X≥T2
```

4. Select threshold T1.

```
THRESHOLDS?

<T1              >
<T2              >
```

5. Set Threshold T1.

```
THRESHOLD?

 _________
```

Alarms for channels 1, 2, 3, and 4 monitor the "displayed value", thus if the reading is scaled, the threshold value must be set up for the scaled value.

Alarms for channels 5, 6, 7, and 8 monitor the decimal value of the input regardless of the display modifier used. Thus, the threshold value must be set up for the decimal equivalent of the input.

The thresholds are numeric entries. The keys to the right of the threshold select the multiplier (m, μ, k, M). Threshold entries are functionless, that is XXXXk can represent XXXXkΩ or XXXXXkHz.

6. Select and set threshold T2 if applicable and press Enter and select the desired responses (table 4-88).

```
RESPONSE?
◀TONE    STORE>
<RUN PROG/LIST
<XMIT  OUTPUT>
```

Table 4-87. Alarm Trigger Conditions

Item	Result of Selection
ENABLED	Enables the alarm. An alarm can be set up and attached to a channel measurement, but if the alarm is not enabled, there will be no alarm response.

Table 4-87. Alarm Trigger Conditions (Continued)

Item	Result of Selection
LATCHED	Alarm goes active and remains active until the channel list ends or LATCHED is deselected.
X≤T1	Alarm triggered when the reading drops below the threshold T1.
X≥T1	Alarm triggered when the reading goes above the threshold T1.
T1≤X≤T2	Alarm triggered when the reading remains between the two thresholds T1 and T2.
X≤T1 OR X≥T2	Alarm triggered when the reading goes below the threshold T1 or above the threshold T2.

Table 4-88. Alarm Response

Item	Result of Selection
TONE	Produces a tone when the alarm condition is true; see paragraph **Tone**.
RUN PROG/ LIST	Allows the unit to run a program or channel list in response to the alarm. The cursor indicates the program to be selected; see paragraph **Program or Channel List**.
XMIT	Transmits the alarm via the RS 232C or IEEE-488 (table 4-90).
STORE	Stores the alarm response in the unit's memory (table 4-91).
OUTPUT	Allows a digital output channel to react to the alarm; see paragraph **Output**.

Any or all responses can be entered. If multiple responses are entered, they will be executed in this order:

OUTPUT
STORE
XMIT
TONE
RUN PROG/LIST

If making a selection does not automatically jump to the next menu, press the Enter key. Example 4-6 demonstrates how to set up an alarm.

Example 4-6 Setting Up an Alarm

This example creates alarm number 1 which produces a warbled tone when the attached channel reading exceeds 78 units of measure. Remember, the alarm values are functionless, that is 78.can represent 78.00Ω or 78.0000Hz.

Step	Action	Display
1	Select ALARMS from the main menu. Hint: use the **Mods** key to locate the ALARMS group.	<MATH <ALARMS <TRACKING <UNIT STATUS
2	Press **1** and **Enter** to enter the alarm number.	ALARM NUMBER? (1-31) 01
3	Select ENABLED and X≥T1. (The < and > will be highlighted.) Press **Enter**.	A01 ENABLED> <X≤T1 LATCHED> <X≥T1T1≤X<_T2> <X<T1 OR X≥T2>
4	Select <T1.	THRESHOLDS? <T1 > <T2 >
5	Press **7**, **8**, and **Enter**.	THRESHOLDS? - - - - - - - - - -
6	Press **Enter**.	THRESHOLDS? <T1 78.0000> <T2 >
7	Select TONE.	REPONSE? <TONE STORE> <RUNPROG/LIST> <XMIT OUTPUT>

Example 4-6 Setting Up an Alarm (Continued)

Step	Action	Display
8	Select MIDF and WARBLE. Select CHK once to preview the tone, then select CHK once again to stop the tone check Press Enter.	TONE: CHK> <LOWF WARBLE> <MIDF PULSED> <HIGHF 30s>
9	Press Enter. (Alarm number 1 has now be created.)	REPONSE? <TONE STORE> <RUNPROG/LIST> <XMIT OUTPUT>
10	Display returns to the main menu.	<MATH <ALARMS <TRACKING <UNIT STATUS

Tone

A tone can be used to alert a local operator that an alarm's conditions are true. When more than one alarm is used, it is best to use different tones for each alarm. This alarm response item calls the Tone menu which allows selection of the type of audible tone. Table 4-89 describes the tone menu items.

Table 4-89. Tones

Item	Result of Selection
LOWF	Low frequency tone when the alarm is active.
MIDF	Mid-frequency tone.
HIGHF	High frequency tone.
WARBLED	Warbled tone at one of the three frequencies.
30s	30 second duration tone.
CHK	Checks the selected tone.

Program or Channel List

This alarm response item selects programs and channel lists to run when alarm goes active. The first menu called is "Alarm Run" as shown.

```
ALARM RUN:
 EXAMPLE.L

<SET
```

Selecting SET calls the second menu, the list of program/channel lists.

For example:

```
<TEST.L      R>
<8CH TEMP.P  R>
<PS EFFIC.L  R>
<4CH DMM.L   R>
```

To select a program or channel list, press the key to the left of the item and Enter to return to the Alarm Response menu. Only one program or list can be inserted in an alarm. The ▲ ▼ cursor keys allow scrolling through the available channel lists and programs.

Transmit

The transmit mode selects what alarm items are transmitted over the RS-232-C or IEEE-488 ports when the alarm condition goes true. Table 4-90 describes the transmit responses.

```
<READING A#7
<READING/TIME
<ALL SCAN DATA
```

Table 4-90. Transmit Responses

Item	Result of Selection
READING	Transmits the reading that caused the alarm.
READING/ TIME	Transmits both the reading and time.
A#	Transmits only the alarm number.
ALL SCAN DATA	Transmits the data taken during the program scan of the alarm occurrence. If the alarm occurs during a scan, the unit transmits all the data in that scan.

Store

This alarm response selects what alarm items are in memory when the alarm conditions are true. Table 4-91 describes the store responses. Stored alarms can be recalled by using Recall Data (paragraph 4.4.3).

```
STORE?
<READING A#?
<READING/TIME
<ALL SCAN DATA
```

Table 4-91. Store Responses

Item	Result of Selection
READING	Stores the reading that caused the alarm.
A#	Store only the alarm number.
READING/ TIME	Stores both the reading and time.
ALL SCAN DATA	Stores the data taken during the program scan of the alarms occurrence.

Output

Digital outputs can send a bit, byte, or analog output that can be used to control external devices such as relays or binary programmable circuits. This item writes a digital output bit, byte or analog output to a Digital I/O connector when the alarm goes active.

```
CHAN?
(510-590,610-690,
 710-790,810-890)
```

When an output channel is selected, a second menu sets up the output Bit, Byte, or Analog Output. **Enter** accepts the output value.

```
OUTPUT VALUE ?
(NUMBERS OR ▲▼)

_________
```

The output values for the proportional analog outputs (X_{90}) and digital output byte (X_{10}) are entered as an eight bit binary value. The proportional output voltage (X_{90}) is a dc voltage that varies linearly between an output value of 00000000 (0V output) and an output value of 11111111 (+2.55V output). The output value for the individual output bit (X_{1y}: X represents the output channel number and Y represents the output bit) is entered as a 0 or 1.

To attach an alarm to a channel

Alarms must be attached to a channel measurement in order to work.

1. Set up the channel to be measured.
2. Press **Mods** to call the function modifier menu and select ALARM.

```
<DELAY
<ALARM
<TRACK
```

3. Enter the alarm number using the numeric or ▲▼ cursor keys.

```
ALARM NUMBER?
  (1-31)

  _ _
```

Only one alarm can be attached to a entry. When an alarm is selected, the conditions and responses are not displayed. Thus, the user must remember the alarm number needed or go back to ALARM in the main menu and check the number. To check the alarm conditions and response the user must call the alarm through the main menu (see Creating Alarms) and step through the responses. Remember, the alarm conditions are functionless, that is XXXXk can represent XXXXkΩ or XXXXXkHz. Example 4-7 illustrates how to attach an alarm.

Changing Alarm Conditions

An existing alarm can be changed by stepping through the alarm menus the same as in creating an alarm.

Deleting An Alarm

A set of alarm conditions and responses can be deleted by locating ALARMS in the main menu, locating the Alarm Number to be deleted, and stepping to the next menu (press **Enter**). The Alarm can now be deleted by pressing **Clear**.

Alarms for Time

Alarms can be attached to channel 9, the time channel. However, when creating the alarm, see **Creating Alarms**, the values (T1 and T2) must be entered in seconds from midnight.

For example: To sound an alarm at 8:00 a.m., enter the value as 28800 (60*60*8) for 28,800 seconds from midnight.

Example 4-7 Attaching an Alarm

This example measures temperature using a type K thermocouple on channel 1. When the temperature exceeds 78.0000 degrees Fahrenheit the alarm sounds. Alarm number 1 was created in example 4-6.

Step	Action	Display
1	Select DMM from the main menu.	<DMM <CHANNEL LIST <PROGRAM <RECALL DATA
2	Press **Chan** and **1**.	ENTER CHAN #: _
3	Press **Enter**.	0.0000 1FP Vdc <Δ Δ%>
4	Press **Func** and select TEMP.	<Vdc TEMP> <Vac OHMS> <Vac+dc dB>
5	Press **Range**.	<K TC E> <J TYPE T>
6	Select K and press **Mods**. This selects a type K thermocouple input.	<DELAY °C> <ALARM °K> <TRACK °F>
7	Select °F and ALARM.	ALARM NUMBER? (1-31) _ _
8	Press **1** and **Enter** to attach alarm number 1 to the thermocouple reading.	<DELAY °C> <DELAY °C> <ALARM °K> <TRACK °F>

Example 4-7. Using an Alarm (Continued)

Step	Action	Display
9	Press **Enter**.	0.0000 1FP °F <Δ Δ%>
10	Connect a Type K thermocouple to the Hi and Lo inputs of channel 1. When the temperature exceeds 78.0000 degrees Fahrenheit the alarm will sound. Hint: pinch the thermocouple between your two fingers.	

4.5.5.3 Tracking

Tracking uses an analog level (0 to + 2.55V) or a digital byte (00000000 to 11111111) to track a channel measurement. Tracking requires an optional Digital I/O card (option 50-14). Tracking conditions must first be set up from the main menu and then attached to a channel list entry.

The output, analog or digital, can be single ended (SE) or bipolar. Single ended output levels vary linearly between a 0 value (0V or 00000000) and a full scale value (+ 2.55V or 11111111); see figure 4-13.

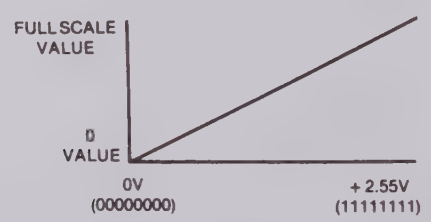


Figure 4-13. Single Ended Outputs

Bipolar outputs vary linearly around a center (0) value (+ 1.28V or 10000000) and a full scale value (+ 2.55V or 11111111). The deviation is the full scale value minus the 0 value; see figure 4-14.

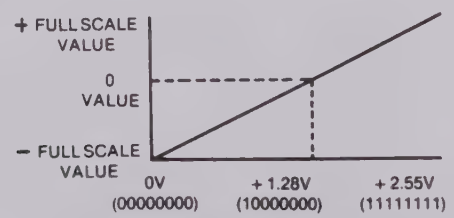
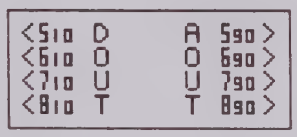


Figure 4-14. Bipolar Output

To Set Up Tracking:

1. Select TRACKING on the main menu to display the output channel listing. Then select the output channel (table 4-92).



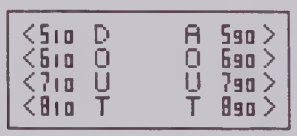
2. Select the track functions. Select single ended (SE) or Bipolar (BIPOLAR). Press the key to the left of 0 or FS to begin entering the values. Pressing the key to the right of the value you have just entered selects the m, k, M, or μ multiplier.

Table 4-92. Tracking Channels

Item	Description
5_{10}, 6_{10}, 7_{10}, and 8_{10}	(DOUT) provides an 8 bit digital output proportional to the channel measurement.
5_{90}, 6_{90}, 7_{90}, and 8_{90}	(AOUT) provides an analog output proportional to the channel measurement.

Using Tracking

Once tracking has been set up, it can be used with channel measurements. To attach Tracking, select the channel list entry's Mods menu, select Track, and select the output channel.



4.5.5.4 CAL-Calibrate

Selecting CAL from the function modifier menu allows calibration of the selected function and range. The functions that require calibration are dc voltage, ac voltage, ohms, dc amperes, ac amperes, cold-junction temperature and frequency. The calibration procedure is covered in the Maintenance Manual.

4.5.5.5 CALO-Calibrate Zero

Selecting CALO from the function modifier menu allows zeroing of each range for the dc Voltage and Ohms functions as often as needed. You will need to use CALO whenever a zero input does not read zero. To zero a range, select CALO and apply a short across the inputs; the resistance of the short must be less than the least significant digit of the range.

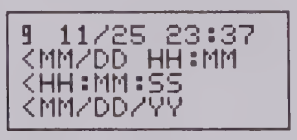
4.5.6 Time/Date Channel

Channel 9, the time/date channel, reads the time, date, or date and time of the Model 52 internal clock. To read the time and date:

1. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List)
2. Press **Chan** followed by **9** and **Enter** to read the time/date.

To change the display format:

3. Press the **Func** key to call the menu which allows you to change the display format. A typical display is:



The first line shows the channel number followed by the date and time; this is the default format. Table 4-93 gives the selectable formats.

Table 4-93. Time and Date Formats

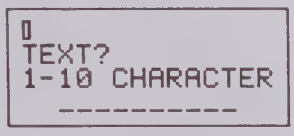
Item	Description
MM/DD HH:MM	Displays the date and time as the month/day and hour:minutes.
HH:MM:SS	Displays the time as hours:minutes: seconds.
MM/DD/YY	Displays the date as month/day/ year.

4.5.7 Text Channel

The text channel (Channel 0 without a subscript) displays text (up to 10 characters). A text channel is displayed, transmitted, and stored as it is read. The text channel can be used like a "PRINT" statement in BASIC.

To create a text channel:

1. Select the mode (paragraph 4.5, DMM; paragraph 4.6, Channel List).
2. Press **Chan** and **0**; remember no subscript is needed. Press **Func** to start entering text. The display is:



3. Use the **▲** **▼** cursor keys to cycle through the characters for the first character position. The characters are: **A**, **B**, **C**, **D**, **E**, **F**, **G**, **H**, **I**, **J**, **K**, **L**, **M**, **N**, **O**, **P**, **Q**, **R**, **S**, **T**, **U**, **V**, **W**, **X**, **Y**, **Z**, ⌐, \, ¬, ^, <_>, □, <blank>, **!**, **"**, **#**, **$**, **%**, **&**, **'**, **(**, **)**, *, **+**, **,**, **-**, **.**, **/**, **0**, **1**, **2**, **3**, **4**, **5**, **6**, **7**, **8**, **9**, **:**, **;**, **<**, **=**, **>**, **?**, and **@**. Stop at the desired character and use the **Enter** key to accept the character. Do the same for each of the remaining character positions.

   (The backslash (\) in a text channel sounds a tone. A text channel with a backslash can be placed ahead of a channel number to signal when the measurement is to be made. Adding backslashes to a text channel increases the length of the tone.)

5. Press **Enter** to accept the text.

4.5.8 Math Channel

A math channel (Channel 0) can calculate a value defined by the user-entered formula (paragraph 4.3.7, Creating a Math Formula). A Math channel can be used in a channel list (paragraph 4.6) the same as any other channel number. The results of the formula are displayed

the same as any other channel reading except they will be labeled MATH (or other assigned label).

The formula uses the readings from preceding channel measurements. Therefore, all channel measurements used in the formula must be taken before being used by the math channel formula.

4.6 CHANNEL LIST/MULTIPLE CHANNEL DMM

A channel list is a group of analog, digital, and special measurements identified in the main menu by a ".L" suffix. Channel lists are also the measurements made by programs. Example 3-2 illustrates the Channel List/ Multiple Channel DMM.

A channel list is used to take measurements. If you wish to store (paragraph 4.4) or transmit (paragraphs 4.4, 5.3, and 5.4) the readings you must preset the storage and transmission conditions before running the channel list.

4.6.1 Entering the Channel List

There are five basic steps to creating a channel list.

1. Press Menu to locate CHANNEL LIST in the main menu and select it.
2. Select Serial or Parallel list.
3. Enter the Channel List Name.
4. Enter the Channel Numbers, Functions, Ranges, Function Modifiers, and Display Modifiers.
5. Select the action to be taken.

4.6.1.1 Entering the Channel List Name

To enter the name, use the cursor keys ▲ ▼ to scroll through the available characters (**A**, **B**, **C**, **D**, **E**, **F**, **G**, **H**, **I**, **J**, **K**, **L**, **M**, **N**, **O**, **P**, **Q**, **R**, **S**, **T**, **U**, **V**, **W**, **X**, **Y**, **Z**, ⌐, ¬, \, ⌐, Λ, <_>, □, <blank>, **!**, **"**, **#**, **$**, **%**, **&**, **'**, **(**, **)**, *, **+**, **,**, **-**, **.**, **/**, **0**, **1**, **2**, **3**, **4**, **5**, **6**, **7**, **8**, **9**, **:**, **;**, **<**, **=**, **>**, **?**, and **@**). When the character is found, press Enter and the character is displayed and the next character can be entered. See example 4-8. Characters are entered from left to right. When the last character is entered press Enter twice to accept the name and advance to the ENTER CHAN #S: menu. Once a Channel List is named it can never be changed.

Example 4-8. Channel List Name Entry

Step	Action	Display
1	Locate and select <CHANNEL LIST.	<DMM <CHANNEL LIST <PROGRAM <RECALL
2	Select SERIAL	NAME? ◀SERIAL PAR> (USE ▲▼ KEYS) _ _ _ _ _ _ _ _
3	Use the ▲ ▼ cursor keys to locate "A". Press Enter.	NAME? ◀SERIAL PAR> (USE ▲▼ KEYS) A_ _ _ _ _ _ _
4	Use the ▲ ▼ cursor keys to locate "1" or press 1. Press Enter	NAME? ◀SERIAL PAR> (USE ▲▼ KEYS) A1_ _ _ _ _ _
5.	Press Enter once again. The Channel List is now named A1.	Ch: _

4.6.1.2 Serial or Parallel Run Lists

Channel lists can be run as serial or parallel lists. A serial list runs in the same order the channel numbers are entered; one channel at a time. A parallel list runs the channels simultaneously; in other words, channels 1, 2, 3, and 4 could all make measurements at the same time. The parallel method is preferable when 1 reading may take a long time (for example, a 7 digit resolution frequency measurement). Example 4-8 illustrates how to select serial or parallel lists. After the list is created, it can be changed from serial to parallel or vice versa.

4.6.1.3 Entering the Channel Numbers

There are two methods for entering channel numbers. One method enters only the channel number and requires returning to the Channel List Edit menu to change the functions, ranges, and modifiers (paragraph 4.6.2, Editing the Channel List). The second method enters the channel number, function, range, and modifiers all at the same time.

Channel Numbers

Channel and subchannel numbers (paragraph 4.5.1) are entered using the numeric keys. The first number entered is the channel number and the second and third numbers are the subchannel numbers. For example: Press 1 followed by 0 and another 0 selects 1_{00}. If only one subscript digit is entered, the Model 52 assumes a leading zero.

Grouping Multiplexed Channels

The multiplexed channels can be entered rapidly as a group rather then individually by programming the channel number, the beginning subchannel number, a dash (± • key), the channel number (same channel number as the start subchannel), and the ending subchannel. For example: $1_{01} - 1_{16}$ scans multiplexed inputs 1 through 16 for channel 1. When measuring temperature with a multiplexer, every set of subchannel numbers for each multiplexer module must include at least one cold-junction temperature measurement.

Entering the Channels Numbers in the List

There are two methods to entering channels in a list. Method 1 sets up the channel numbers first and uses editing to set up channel parameters. Method 2 sets up channel parameters all at once.

Method 1 — To enter just the channel numbers:

1. Enter the channel and subchannel number or channel group and press Enter. This accepts the channel number and moves on to the next channel number entry.
2. Continue until all channel numbers are entered.
3. Press Enter twice to complete the channel list and return to the Main Menu.

The new list must be edited in order to change the functions, ranges, display modifiers, and function modifier (paragraph 4.6.2).

Method 2 — To enter the channel number along with the function, range, and modifiers:

1. Select the channel and subchannel number or channel group
2. Select the function (press the Func key; paragraph 4.5.2)
3. Select the range (press the Range key; paragraph 4.5.2).
4. Select the display modifier (press Disp key; paragraph 4.5.4).
5. Select the function modifier (press Mods key; refer to paragraph 4.5.5).
6. Press Enter to move to the next channel entry.

4.6.1.4 Channel List Action

After all the channel numbers, functions, ranges, and modifiers have been entered, the channel list's action menu is displayed.

This menu selects what will be done with the channel list. A list can be edited (paragraph 4.6.2), deleted (paragraph 4.6.3), run (paragraph 4.6.4), or transmitted (paragraph 4.6.5). To do nothing with the channel list, press Menu which returns you to the main menu.

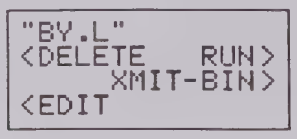
4.6.2 Editing a Channel List

Editing allows changing the conditions of an existing channel list.

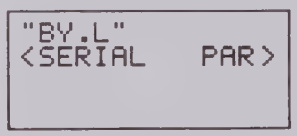
To Edit the Channel List:

1. Locate the desired channel list from the main menu and select it using the left "<" key. Note: selecting the "R" runs the list.

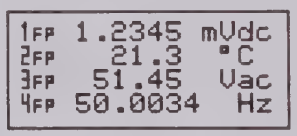
2. Selecting the channel list calls the channel list action menu:



3. Select EDIT from the action menu to display the channel list.

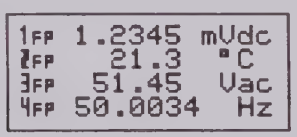


4. Serial or Parallel operation may be changed; press **Enter** to the channel list. A typical channel list is:



Use the ▲ ▼ keys to scroll through the channel list. The Display Mode (paragraph 4.3.1) sets up how the list is displayed. Automatic scrolling is disabled while editing a channel list.

5. Select the channel number to be edited by pressing the key to the left of the channel number. This highlights the channel number to be edited.



6. Change function, range, and modifiers.

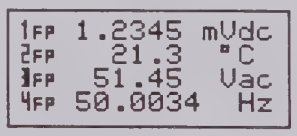
   Func allows changing function (paragraph 4.5.2).
   Range allows changing range (paragraph 4.5.2).
   Disp allows changing display modifiers (paragraph 4.5.4).
   Mods allows changing function modifiers (paragraph 4.5.5).

To Add a New Channel to a Channel List While in the Edit Mode:

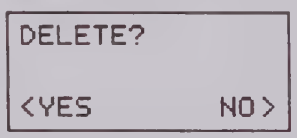
1. Select a channel. The new channel will follow the selected (highlighted) channel.
2. Press **Chan** key (paragraph 4.5.1).
3. Enter the new channel number.
4. Enter the function, range, and modifiers (paragraphs 4.5.2, 4.5.4 and 4.5.5).
5. Press **Enter** to accept the new entry.

To Delete a Single Channel Number from the Channel List While in the Edit Mode:

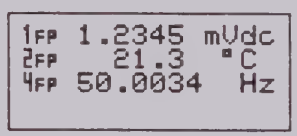
1. Select a channel number from the channel list by pressing the key to the left of the channel number. The channel number to be deleted is highlighted.



2. Press the **Clear** key to call the delete menu:



3. Select YES to delete the channel number from the list or NO to save the entry.

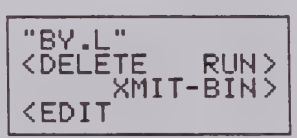


4.6.3 Deleting an Entire Channel List

To delete a complete channel list from memory:

1. Locate the desired channel list from the main menu and select it. Note: selecting the "R" runs the list.

2. Selecting the channel list calls the channel list's action menu:



3. Select DELETE to call the delete menu:

```
DELETE?

<YES          NO>
```

4. Select YES to delete the entire channel list or NO to save the channel list.

```
<EXAMPLE.L   R>
<XXXXXX.L    R>
<YYYYY.P     R>
<DMM
```

4.6.4 Running a Channel List

To Run the Channel List:

1. Locate the channel list in the main menu (using ▲ ▼.

```
<EXAMPLE.L   R>
<XXXXXX.L    R>
<YYYYY.P     R>
<BY.L        R>
```

2. Select "R" to run the list, or press the key to the left of the channel list name to call the channel list action menu (paragraph 4.6.1.5) and select "RUN".

To Edit a Channel List Making Measurements

If a channel list is making measurements, but not scrolling (paragraph 4.3.1), the channel list can be edited the same way as described in paragraph 4.6.2).

If a channel list is making measurements and automatically scrolling through the readings, the channel list must be stopped before being edited. To edit a running channel list,

1. Press Enter to stop the scrolling list.
2. Edit the list as described in paragraph 4.6.2.
3. Press Enter once again to restart automatic scrolling.

4.6.5 Channel List Transmit

A channel list can be transmitted over the RS-232-C or IEEE-488 ports. If the channel list is to be used with a program, the channel list and program must be transmitted separately. The channel list is transmitted as a binary file in ASCII format.

4.7 PROGRAMS

Programs consists of channel lists (up to 64), start conditions, scan intervals, stop conditions, and end conditions. This section describes how to create, edit, run, and delete a program.

A program calls channel lists that take the measurements. If you wish to store or transmit the readings you must preset the storage (paragraph 4.4) and transmission (paragraphs 4.4, 5.3, and 5.4) conditions before running the program.

4.7.1 Creating Programs

The following steps create a program. Example 3-3 illustrates a program creation.

1. Locate PROGRAM in the main menu and select it.

```
<DMM
<CHANNEL LIST
<PROGRAM
<RECALL DATA
```

2. Enter the program name (paragraph 4.7.1.1).

```
NAME?
 (USE ▲▼ KEYS)
 --------
```

3. Select the start conditions (paragraph 4.7.1.2).

```
 STRT DD HH:MM
<▲t  ▲00 00:00
<RTCLK   ASAP>
<ʃ EXTTRIG  ʅ>
```

Selecting either EXTTRIG selection will call the start Trigger menu (table 4-96):

```
  TRIGGER #:
(5ox-8ox or 1-4)
     ---
```

4. Select the channel lists for the program and set the number of repetitions of a channel list (paragraph 4.7.1.3).

```
CALL: CH LIST>
```

5. Set the scan interval (paragraph 4.7.1.4).

```
SCAN INTERVAL
 DD HH:MM:SS
 00 00:00:00
<SET    CONTIN>
```

6. Select the stop conditions (paragraph 4.7.1.5).

```
STOP  DD HH:MM
<▲t   ▲00 00:00
<RTCLK    SCAN>
<ʃ EXTTRIG  ٦>
```

Selecting either EXTTRIG selection will call the stop trigger menu (table 4-99):

```
  TRIGGER #:
<5ox-8ox or 1-4>
      ---
```

7. Select the program termination.

```
PRGM END:
<RUN-P/L STOP>
```

Selecting RUN-P/L will call a list of channel lists; for example:

```
<EXAMPLE.L
<XXXXX.L
<YYYYYY.P
<BY.L
```

8. Select the program action item, then press Enter.

```
"YYYYYY.P
<DELETE    RUN▶
      XMIT-BIN>
<EDIT      LOCK>
```

Selecting DELETE deletes the entire program (paragraph 4.7.4). Selecting RUN starts the program (paragraph 4.7.3). Selecting XMIT-BIN transmits the program setup (paragraph 4.7.6). Selecting EDIT allows you to change or check the program (paragraph 4.7.2). Selecting LOCK allows you to lock out the front panel while the program is running (paragraph 4.7.5).

4.7.1.1 Program Name

The next step is entering the program's name. To enter the program name, use the cursor keys ▲ and ▼ to scroll through the available characters (**A**, **B**, **C**, **D**, **E**, **F**, **G**, **H**, **I**, **J**, **K**, **L**, **M**, **N**, **O**, **P**, **Q**, **R**, **S**, **T**, **U**, **V**, **W**, **X**, **Y**, **Z**, ʃ, \, ٦, ∧<_>, □, <blank>, **!**, **"**, **#**, **$**, **%**, **&**, **'**, **(**, **)**, *, +, ,, -, ., /, **0**, **1**, **2**, **3**, **4**, **5**, **6**, **7**, 8, **9**, :, ;, <, =, >, **?**, and **@**). When the character is found, press Enter and the character is displayed; characters are entered from left to right. The next character now can be entered and so on until the name is completed. A program name can contain up to eight characters. When the last character is entered press Enter twice to accept the name and advance to the START menu.

4.7.1.2 Start Conditions

Start conditions (START menu) determine how the program begins running. Table 4-94 describes the items from the start condition menu.

Table 4-94. Start Cautions

Item	Description
Δt	The time the unit waits before beginning the program. The ΔT time is in days (up to 99 days), hours (24 hour clock), and minutes. For example, select ΔT then press the numbers 11 followed by 1200. The program will be run 11 days and 12 hours after being initiated.

Table 4-94. Start Cautions (Continued)

Item	Description
RTCLK	The actual time a program will start. The Real Time clock is in delta days (up to 99 days), hours (24 hour clock), and minutes, actual time of day. For example, select RTCLK then press the numbers 11 followed by 1200. The program will start in 11 days at 12 o'clock noon.
ASAP	Program starts immediately.
EXTTRIG	Selects the trigger input. A Digital I/O card (Option 50-14) must be installed to trigger a program. A channel number must be entered (table 4-96).
⌐	The program starts when the external trigger reaches a "high" level. With no trigger input connected (open circuit), the program starts immediately.
⌙	The program starts when the external trigger reaches a "low" level. All trigger inputs are pulled high, therefore, a contact closure could start the program when ⌙ EXTTRIG is selected. With no trigger inut connected (open circuit), the program never starts.

Table 4-95. Start Trigger

Item	Description
1-4	Enter a 1, 2, 3, or 4 to select External Trig 1, 2, 3, or 4 inputs on the digital I/O connector (see paragraph 2.3.8). An input transition on the selected input will start the program. Software versions before 4.23G will not allow programs to be triggered using the EXTERNAL TRIG 1, , 3, and 4 inputs.
5_{0x} – 8_{0x}	Enter a digital input bit channel number to start a program. Enter either channel 5, 6, 7, or 8; the subscript "x" identifies the individual trigger bit. An input transition on the selected digital I/O input will start the program (paragraph 2.3.8).

4.7.1.3 Selecting Channel Lists

After selecting the start conditions, press Enter to step the CALL menu which allows selection of the channel lists. The channel lists are used by a program to make the actual measurement.

The CALL menu shows the channel lists in the program. To add a channel list to the program, select CH LIST> to display a listing of channel lists.

This list allows you to select the channel lists for the program. These lists must already exist. However, new lists can be created and inserted in the program later.

To add a channel list to the program, press the key to the left of the list's name and press Enter. This returns to the CALL menu. If more than four channel lists are in the list, the cursor ▲ ▼ keys can be used to scroll through the list. Selecting the left arrow in a CALL menu inserts a new list right after the selected list. To delete a channel list from the CALL menu, select the list and press the Clear key.

Channel List Repetitions

The selected list now appears in the list shown on the CALL menu. To the right of each channel list name is the repetition number (initially X01). This is the the number of times the channel list repeats. To change the number of repetitions, press the key to the right of the channel list. Then, enter the number (1 to 98, 99 allows continuous repetitions). Press Enter to step to the SCAN INTERVAL menu.

4.7.1.4 Scan Interval

The scan interval menu allow selection of the time the program waits before running the channel lists again. Table 4-96 describes the scan interval menu items. Pressing Enter accepts the scan interval and advances to the STOP menu. Scan interval depends upon how long it takes for a list to take its measurements.

Table 4-96. Scan Interval

Item	Description
SET	Allows setting the scan interval in days, hours, minutes, and seconds (99 days, 23 hours, 59 minutes, and 59 seconds maximum).
CONTIN	Selects continuous scans.

4.7.1.5 Stop Conditions

The stop menu allows selection of the conditions (see table 4-97) that will stop the program.

Table 4-97. Stop Conditions

Item	Description
Δt	The time the unit runs the program. The ΔT time is in days (up to 99 days), hours (24 hour clock), and minutes. For example, select ΔT then press the numbers 11 followed by 1200. The program will be run 11 days and 12 hours after the program is started.
RTCLK	The actual time a program ends. The Real Time clock is in days (up to 99 days), hours (24 hour clock), and minutes, actual time of day. For example, select <RTCLK then press the numbers 11 followed by 1200. The program will run for 11 days and end at 12 o'clock noon.
SCANS	The number of times the channel lists will repeat. The channel lists can be scanned up to 9998 times; 9999 continuously repeats the channel lists.
EXTTRIG	Selects the trigger input to stop the program. A Digital I/O card (Option 50-14) must be installed to trigger a program. A channel number must be entered (table 4-99).
⌐	The program stops when the external trigger reaches a "high" level. With no trigger input connected (open circuit), the program stops after one scan.
⌐	The program stops when the external trigger reaches a "low" level. With no trigger input connected (open circuit), the program never stops. All trigger inputs are pulled high, therefore, a contact closure could stop the program when EXTTRIG is selected.

Table 4-98. Stop Trigger

Item	Description
1 – 4	Enter a 1, 2, 3, or 4 to select EXT1, EXT2, EXT3, or EXT4 inputs on the digital I/O connector (paragraph 2.3.8). An input transition on the selected input will stop the program.
5_{ox} – 8_x	Enter a digital input bit channel number to stop a program. Enter either channel 5, 6, 7, or 8; the subscript "x" identifies the individual trigger bit. An input transition on the selected digital I/O input will stop the program (paragraph 2.3.8).

4.7.1.6 Program End

Program end (PRGM END) determines what happens when a program is finished. One choice is STOP which simply stops the program when it is finished

Another choice is run Program/Channel list (RUN-P/L) which permits programs and channel lists to be initiated when the first program ends. In fact, a program can even loop around and run itself. Before having a program run itself, be sure to check the programs start and stop conditions. These programs and channel lists appended to a program can be used just like the first program to take measurements, log data, and control external devices.

4.7.2 Editing the Program

To edit an existing program, locate the program in the main menu listing (press **Chan** while in the main menu).

From the program action menu, select <EDIT to bring up the start condition menu. The method for changing a program is the same as used in creating the program (paragraph 4.7.1). That is, once the menu to be changed is found, make the changes, and press **Enter** to accept the changes and continue on through the program. Pressing **Enter** accepts the setup in the menus as correct and advances to the next menu. This same method is useful in reviewing program content.

4.7.3 Running the Program

To run a program directly from the main menu, locate the program name in the main menu listing and select R to the right of the program name.

To run a program from the program action menu, select RUN and press Enter. A typical display follows. If RUN is already highlighted, either press Enter or the key to the right of RUN.

```
"PTEST.P
<DELETE    RUN▶
      XMIT-BIN>
<EDIT     LOCK>
```

Monitor Mode

The monitor mode allows you to

- Check time time until the next measurement scans.
- Turn off the power between scans to conserve power.
- Call a channel list which will make continuous measurements until the next program scan.

The monitor mode can be set up either from the main menu or a running program.

Setting the Monitor Mode from the Main Menu

Locate and select MONITOR MODE in the main menu (press Disp to quickly locate MONITOR MODE). Making selections from this menu (see table 4-99) selects what happens between scans in a program.

Table 4-99. Monitor Mode

Item	Result of Selection
PWR DOWN	Turns off power between scans of the program.
NEXT SCAN t	Displays the time until the next scan.
MONITOR LIST	Runs a monitor channel list between scans.

Setting the Monitor Mode of a Running Program

While the program is running, the monitor mode can be changed by selecting MONITOR from the program screen. This calls the same Monitor Mode menu as described in **Setting the Monitor Mode from the Main Menu**. However, when this selection is entered (press Enter) the action takes place immediately.

If Monitor Mode PWR DOWN was selected, the program can be stopped or monitor mode changed by pressing the Power key. This displays the program menu for a few seconds. While the program menu is displayed, STOP can be selected to end the program or MONITOR can be selected to change the Monitor Mode.

If Monitor Mode Monitor List was selected, the monitor list can be stopped by pressing the Menu key. This returns the unit to the main menu. But, the program maintains control and will return to the program's channel lists at the next scan. Also, a program can be stopped while the monitor list is running by pressing the Clear key. A typical Monitor Mode display is:

```
PTEST      00001
▲t=00 00:00:26
RT=00 09:05:35
<STOP MONITOR>
```

Table 4-100. describes the Monitor Mode display items.

Table 4-100. Monitor Mode Screen

Item	Description
PTEST	Program name (an example).
00001	Scan number.
Δt =	Count down until next scan.
RT =	Real Time of next scan.
STOP	Allows program to be stopped.
MONITOR	Allows changing of Monitor Mode.

4.7.4 Deleting the Program

An entire program can be deleted selecting DELETE from the programs action menu. A second menu gives you a second chance.

4.7.5 Program Lock

An item in the program action menu program lock allows you to enter a code (up to four digits) that prevents unauthorized persons from stopping of the program.

Enter the code using the number keys. Remember the code, otherwise the only way to "crack" it is to remove the RAM battery which also destroys the calibration.

Enter the code to regain manual control.

Program lock is disabled at the program's end, and a new code entered to lock out manual control. If a lock code is entered but the program not run, the codes is disabled.

4.7.6 Program Transmit

A program can be transmitted over the RS-232-C or IEEE-488 ports for external storage. The transmitted program stores only the program information and not the channel lists called by the program. The channel lists must be transmitted by XMIT-BIN from the Channel List menu. The program is transmitted as a binary file in ASCII format.

SECTION 5
REMOTE OPERATION

5.1 REMOTE INTRODUCTION

Section 5 describes how to operate the Models 51 and 52 over the RS-232-C or optional GPIB (IEEE-488) data link. For connection drawings, see sections 2.3.4, 2.3.5, and figure 2-8.

The Models 51 and Model 52 work virtually identically in remote. The text in places assumes that you are using a Model 52. Model 51 users, of course, won't have the local display type of feedback. There are only four commands that are unique to the Model 51: **CNF?**, **DT?**, **ID?**, and **MEM?**. There is also a variation of the **CAL** command unique to the Model 51.

Capabilities of the Models 51 and 52 In Remote

In remote the units have all of the measurement capabilities of the Model 52 local mode, with the exception of the DMM mode (single measurement-setup with no name). As with the Model 52 in local, in remote the Models 51 and 52 can be set up with channel lists, programs, math channels, text channels, alarms (setpoints), and tracking parameters. In addition, (normal) data and alarm (exception) data can be transmitted — either in real time, or later, by recall from the units' memory. The text channel can contain messages that get activated under exception (out of limits) conditions, and transmitted to a remote operator.

The program lock feature of local operation is not available to a remote operator. The Model 51, but not the Model 52, transmits a message to the remote operator when the internal alkaline or nicad battery pack is low. The message is BATTERY LOW — 20% LIFE LEFT, CR, LF.

Memory status (bytes available) and configuration (options installed and software version) menu information are read by a local operator from Model 52 main menus. This information cannot be accessed by a remote Model 52 operator. A remote Model 51 operator can access this information using the **ID?**, **CNF?**, and **MEM?** commands.

Information as to what channel list or program is currently running is available to a remote operator by doing a READ (para. 5.7.22) of a text channel "header" (user set up) in the currently running channel list. Data specific to a channel number (including the entry number in a channel list) can be read. The Digital I/O card or cards' digital inputs (bit or byte) can be read without setting up a channel list or program.

A remote operator can control a single output bit, or the complete output byte, on any of the four optional Digital I/O cards. This is useful for control purposes. An analog value can also be sent to the digital to analog converter on the same board.

The order of explanation in section 5 will be Models 51 and 52 remote programming, then RS-232, then GPIB. You may wish to refer to either the RS-232 (paragraphs 2.3.4 and 5.8) or GPIB (paragraphs 2.3.5 and 5.10) sections until the communications link is working, then come back to this point. A working link can be verified by sending "!", then "DIR", from the controller or terminal to the Model 51 or 52. If the electrical link is good, the Model 51 or 52 will echo the characters back. (Echo mode is a default condition.) If the main menu controlling the user's particular link is correctly set, the unit will also respond to the "DIR" command with a directory of lists and programs (if any), terminated by "*END". (You can manually set the Model 52 IEEE-488 and RS-232-C main menus.)

5.2 REMOTE PROGRAMMING OVERVIEW

The programming part of this section explains how to use a remote terminal or controller to accomplish the same things as when manually selecting items in the Model 52 menus; for example, taking measurements and transmitting in real time, or storing the data and recalling it later.

Whether you are using a Model 51 or 52, it is essential to have read the operation overview (section 3). It is also often helpful to have an acquaintance with the manual operation of the Model 52. If use of a programming command explained in terms of remote programming is not clear, you may gain some insights by referring to the equivalent menu, in section 4.

In remote, the relationship of the unit's channel list and program is the same as it is for local (manual) operation. In remote there is no formal equivalent of the single channel DMM mode, since no measurement instructions can

be passed to the unit without a name. So, to set up to measure a single value, a channel list (e.g., DMM.L) must be created.

The unit's remote commands will be explained in alphabetical order. The many instructions under the Models 51 and 52 channel list level are called mnemonics. These are organized under the remote command "ENTL". The instructions under the Models 51 and 52 program level are also called mnemonics — they are organized under the remote command ENTP.

Remote programming "stuffs" the unit's registers that contain information on what front panel key was pushed, and in what order. This is basically true even if your unit has no front panel. In manual operation, your eyes give you feedback on whether you've wandered off into the wrong menus. In offsite remote operation, there is no feedback this way, so attention to proper syntax is very important. (Initial debugging of a list or a program on site can be aided by including a DISP ENAB command, allowing the Model 52 display to react as if in local.)

The remote programming language uses spaces, colons, commas, semicolons, and carriage returns to define the proper levels. The correct syntax keeps you at the proper levels — in effect keeps you in the proper menus. So trying to learn syntax by experimentation at the keyboard, therefore, has far-reaching risks. It is wiser to limit your experimentation to finding out if certain values will be accepted as ranges or modifiers, etc. (Better yet, read this manual.) Note that although you may be able to disorder your own program, you can't hurt the unit by experimenting — its "operating system" is stored in ROM. A simple remote INIT command, or a local power-on clear, restores everything to a known state (the default conditions).

Before learning each instruction in detail, you should familiarize yourself with the following examples. This will begin to give you a feeling for the syntax and structure. Although blank lines may occur for clarity in the examples, none should be used in real entry. The first example shows how short a remote channel list can be.

5.3 EXAMPLES WITH COMMENTS

Example 5-1. Dumb Terminal Channel List

Remote channel lists or programs can be entered and run using any dumb or smart terminal, or any computer using only terminal mode. This includes most personal computers. This list was run on both a DEC VT52 terminal and a Radio Shack Model 200 lap-top battery-powered computer.

Entries	Explanation
!	The exclamation point puts the Model 52 in remote mode. (Model 51: not needed.) Now, it will interpret remote commands. Not shown are a carriage return and line feed, which put the next command on the next line for clarity. (cr and lf are optional after a "!".)
DISP ENAB	This command is optional — turns on local display. Since there is no delimiter (colon, comma, or semi colon), the unit knows this is a stand-alone command.
ENTL SER:COLDTEMP;	Tells the unit we are going to enter a channel list into memory, and label it "COLDTEMP.L". Since the line ends with a semicolon, the Model 51 or 52 knows there is more of the ENTL command sequence to follow.
3:CJT	On channel 3, measure the cold junction temperature. Since Celsius is the default, we get it in that form without having to specify it. If we'd wanted the data scaled in Fahrenheit, we'd have to tack on ":" and the mnemonic "F", to make "3:CJT:F". Colons indicate to the unit that a step down in (menu) hierarchy is taking place. Since there is no semicolon at the end of the line, the unit knows this is the end of the channel list.
DATA XLST	Sets up the DATA ROUTING menu so that any data a channel list acquires, is transmitted.
XMIT CONT	Sets up the TRANSMIT/MEM menu so that the data readings are transmitted continuously, regardless of whether memory is full or not, and not to wait until the channel list is finished. (This list never finishes. Repeats the 3:CJT step automatically.)

Example 5-1. Dumb Terminal Channel List (Continued)

Entries	Explanation
RUN COLDTEMP.L	This tells the unit to find the channel list in memory labeled "COLDTEMP.L" and run it. If you did this example, data would now be appearing on your terminal. (The unit appends ".L" or ".P" to list or program names once they are in memory.)

If you are "on-site" with the Model 52 you could leave out the DATA XLST and XMIT CONT commands and just check manually that the DATA ROUTING and TRANSMIT/MEM menus are set correctly. This is a typical approach to on-site programming.

5.3.1 Comments on Example 5-1.

Each time a reading was taken, you would get a line that looks like:

3:fp 22.45 CJdegC

(Your temperature would be slightly different.) The "3" is the channel number, the "fp" means front panel, then the temperature, then "CJdegC", meaning cold junction temperature in degrees Celsius.

The data flow to the terminal will pause if you send a control S (XOFF). To start it again, send a control Q (XON). (Until control Q is sent, the Model 51 or 52 also will not look at its front panel keys.) If you simply send a **carriage return, it will stop this or any other running channel list**. To start it again: Type "run coldtemp.l" or "RUN COLDTEMP.L". The unit is still in remote, but it has exited the channel list.

The default mode for local front panel control (see GOTO command) is that pushing any button will return to local, so this is also a way of stopping the channel list. Remember that you'll have to send the Model 52 a "!" (to put it back in remote) before a command such as "RUN COLDTEMP.L" will be responded to.

Note that the colon in "3:CJT" signified a step down in hierarchy. When the reading was transmitted, the colon in "3:fp" also kept this convention, suggesting a step down in "hierarchy".

Each reading will be transmitted as soon as it is taken, assuming the baud rate can keep up. If the baud rate can't keep up, the Model 51 or 52 won't take another reading until the last one is sent. Also, If there were more than one item to be measured in our channel list, and it was a serial list (non-default condition for the ENTL command), the other measurements would be delayed. This is because a serial list takes readings in order, one at a time.

If it were a parallel list (ENTL PAR:COLDTEMP;), it could have up to 64 channels; One reading for each channel would be taken and none would be held up by the RS-232 (or GPIB) transmit buffer. While the readings will be taken, they won't be processed until the transmission catches up with that particular entry. For example, if an alarm is attached to one channel, until that channel reading is processed, the action associated with that alarm won't be done.

One way to avoid the limitations of printer speed is to save the data in memory, and transmit it later at a slower rate. Another way is to get one of the many inexpensive standalone printer buffers. These two ways require no computer at the receiving end. If there is a computer, it's memory can be used as the buffer.

In the example above, the Model 52 is taking a reading about every 155 milliseconds. At 9600 baud, it takes only about 21 milliseconds to transmit the line, so the data link is idle a lot of the time. At 1200 baud, it takes about 168 milliseconds to transmit the line. So at 1200 baud, the Model 52 is held up by the RS-232 link a short time. Model 52 reading rates can be speeded up by turning off the display (**DISP** DIS).

If slowing down the data acquisition rate is preferred, a short delay can be inserted between the unit's measurements. When entering the channel list into the unit (ENTL command), the function modifier DLY is used. Excluding the "ENTL SER:COLDTEMP;", the channel list would look like

3:CJT:F,DLY:200

to have a delay of 20.0 seconds **between** each measurement. Let's say you want to measure cold junction temperature and time at the same time, and then wait 20 seconds for the next data point. The delay is before the cold junction measurement. The channel list would look like:

3:CJT:F,DLY:200;
9:HMS

If the above list were run, each data point would come out on your terminal or printer without any space between them. If you want a blank line in between each point for readability, a text reading from channel 0 is required. The list will scan channel 0 (empty, in this case) — and read out no text. The channel list would look like:

```
3:CJT:F,DLY:200;
9:HMS;
0:
```

The DLY modifier can accept a count only up to 255. If a longer delay is desired, the scan interval selection, TIME, for a **program** can be used. The program mode is discussed in detail under the **ENTP** command.

In the example above, we implicitly used the **XMIT** command to make the unit transmit continuously. If we had wanted data to be transmitted only on demand, the remote command **READ** must be used. You would send it as: READ 3: or READ CH3:. (If you had a multiplexer on the input of channel 3, and you wanted subchannel number 7 on that mux, you would send READ 3:07 or READ CH3:07). The Model 51 or 52 would return the latest reading (assuming the channel list is running). It will work regardless of the settings of DATA or XMIT, although normally they would be off. The READ command can also be used to return a specified entry in a channel list. Take the list

```
ENTL SER:TEST;
2:VAC:AUTO;
1:VAC:3;
2:FREQ
```

If you want to know the frequency for channel 2, you would send READ 2:2 — the second 2 being the entry number.

The READ approach requires intelligence at the receiving end. The XMIT approach does not require that the person or place receiving data (perhaps at a later date) know anything about the instrument. All they have to do is hook their serial printer (or modem) up.

Note that if readings are being taken every 20 seconds and you want the reading that occurred 100 seconds after the start of the test, READ is not appropriate. READ does not return data after the fact. The alternative is to use the **RCL** command. You can limit the amount of data that is returned, somewhat, by recalling beginning with a certain time or (program) scan number (see RCL TIMX and RCL CHNX).

The amount of data that is acquired in the first place can be limited when the channel list is embedded inside a (Model 51 or 52) program and there is a pause between channel list scans (see ENTP command). This allows longer "dead times" than the 25.5 seconds available to a channel list measurement alone.

5.3.2 Comments on Examples 5-2 and 5-3

Examples 5-2 and 5-3 show how Model 51 or 52 commands can be embedded inside a computer program. These Channel List examples are written in BASIC. The electrical link for the first is RS-232, for the second, GPIB.

Although the following two lists don't appear to be doing anything with the measurements they are taking, two things could be happening. First, the RS-232 or GPIB port could have been manually set up. Each reading could be going out one or both ports in real time. Second, memory storage may have been manually enabled for data generated by channel lists. Then the data could be recalled from memory later, using the RCL command.

Example 5-2. RS-232-C Computer Program

This example (similar to example 3-2) sets up the unit to measure ac volts, temperature, and time and date. The unit must be manually configured ahead of time to be compatible with the initial RS-232 parameters the computer is going to use. This program is written in BASICA on an IBM PC. It will place the Model 51 or 52 in remote, clear the unit's memory, load a channel list into the unit, run it, and ask the unit to send one temperature reading. The channel list measurements will also be displayed on the Model 52's screen. A line for line explanation accompanies the program so the user can translate the program to run on different computers with RS-232-C ports.

Program	Explanation
100 REM PROGRAM NAME 52 RS232 EXAMPLE 200 REM DATE May 4, 1987 300 OPEN "COM1:9600,N,8,1,CS0" AS #1	Sets up the PC's RS-232-C comm port #1. Baud rate: 9600, no parity checking, 8 data bits, 1 stop bit, ignore CTS line.

Example 5-2. RS-232-C Computer Program (Continued)

Program	Explanation
400 PRINT#1, "^"	Turns off echo of Model 51 or 52.
500 PRINT#1, "!"	Places Model 52 in remote mode.
600 PRINT#1, "R232 RTON,BAUD:1"	Sets the RS-232 conditions: receive and transmit on, 9600 baud. (This is only an example. If RS-232 is not previously set up correctly, we can't communicate with the unit up to this point.)
700 PRINT#1, "STAT 60 HZ"	Turns off power save mode.
800 PRINT#1, "ENTL SER:TEST;"	To enter a serial channel list named "TEST".
900 PRINT#1, "2:VAC:3;"	Sets up channel 2 to measure ac voltage on the 3V range.
1000 PRINT#1, "1:TEMP:K;"	Sets up channel 1 to measure temperature using a type K thermocouple in degrees C (default).
1100 PRINT#1, "9:MDHM"	Sets up channel 9 to read time and date in months, day, hour, and minutes. End of channel list entry.
1200 PRINT#1, "DISP ENAB"	Enables the display.
1300 PRINT#1, "RUN TEST.L"	Runs the channel list.
1400 PRINT#1, "READ 1:"	Tells the Model 51 or 52 to transmit the current temperature measurement.
1500 INPUT #1, N$	Computer reads its input port.
1600 IF N$ = "E8" THEN 1400	E8 is returned if the measurement is not ready.
1700 PRINT N$	Puts the temperature reading returned by the Model 51 or 52 on the computer screen.
1800 CLOSE#1	Closes the com file.
9999 END	

Example 5-3. IEEE-488 Computer Program

This example (same as example 5-2) sets up the Model 51 or 52 to measure ac volts, temperature, and time and date. This program is written for an WTK 6000 GPIB instrumentation controller. It will place the Model 51 or 52 in remote, clear the unit's memory, load a channel list into the unit, run it, and ask the unit to send one temperature reading. The channel list measurements will also be displayed on the Model 52's screen. A line for line explanation accompanies the program so the user can change the program to run on a different computer with an IEEE-488 port.

Program	Explanation
100 REM PROGRAM NAME 52 IEEE-488 EXAMPLE	
200 REM DATE 20 OCTOBER 1986	
300 WRITE @709: "!"	Places unit in remote.
400 WRITE @709: "GPIB RTON,ADDR:9"	Sets the IEEE-488 conditions: receive and transmit on, address is 9. (Like the RS-232 example, this step is redundant, but included to show how to change comm parameters.)

Example 5-3. IEEE-488 Computer Program

Program	Explanation
500 WRITE @709: "STAT 60HZ"	Turns off power save mode.
600 WRITE @709: "ENTL SER:TEST;"	To enter the serial channel list named "TEST".
700 WRITE @709: "2:VAC:3;"	Set up channel 2 to measure ac voltage on 3 V range.
800 WRITE @709: "1:TEMP:K;"	Set up channel 1 to measure temperature using a type K thermocouple in degree C (default).
900 WRITE @709: "9:MDHM"	Set up channel 9 to read time and date in months, day, hour, and minutes. End of channel list entry.
1000 WRITE @709: "DISP ENAB"	Enables the display.
1100 WRITE @709: "RUN TEST.L"	Runs the channel list.
1200 WRITE @709: "READ 1:"	READ 1: tells the Model 51 or 52 to transmit the current temperature measurement.
1300 READ @709:N$	Controller reads its input port.
1400 IF N$ = "E8" THEN 1200	E8 is returned if the measurement is not ready.
1500 PRINT N$	Puts the temperature reading returned by the Model 51 or 52 on the controller's CRT.
9999 END	

Example 5-4. Alarms and Channel List-Switching

The following hypothetical example shows the use of alarms and alarm responses to switch between two lists. Math formulas are also used to scale a voltage reading according to which list is currently operating.

Channel 1 in both lists measures the room temperature. In list SWITCH1, as long as the list is below 30 °C, the second entry (VDC) will be scaled by math function 01, which squares the voltage reading. Should the room temperature exceed 30 °C, an alarm condition is met, and list SWITCH2 is called. This list will also monitor the room temperature, and will continue to operate as long as the temperature exceeds 20 °C. The voltage reading on channel 2 is now scaled by a different function (MATH 17). Should the temperature go below 20 °C, ALARM 02 will call list SWITCH1 again.

This is all done by the following remote entries.

Entries	Explanation
!DISP ENAB	Go to remote; turn on local display
ENTL SWITCH1; 1:CJT,ALRM:01; 2:VDC,SCAL:01	Name of this list is SWITCH1. Measure temp., check against ALRM 1. Measure VDC, display the result of MATH 01.
ENTL SWITCH2; 1:CJT, ALRM:02; 2:VDC,SCAL:17	Name of this list is SWITCH2. Measure temp., check against ALRM 2. Measure VDC, display modifier is MATH 17.
ALRM 1; GTE; T1:30.0; TONE:HIGH,RUN:SWITCH2.L	 If greater than or equal to 30, make a high-frequency tone, and run SWITCH2.L

Example 5-4. Alarms and Channel List-Switching (Continued)

Entries	Explanation
ALRM 2; LTE; T1:20.0; TONE:LOW,RUN:SWITCH1.L	 If less than or equal to 20, make a low-frequency tone, and run SWITCH1.L
MATH 01; X*X; XSQR	 Square X. (Only X*X will be displayed.)
MATH 17; SQRTX; SRTX	 Take the square root of X.
RUN SWITCH1.L	Start by running the list SWITCH1.L

Example 5-5. Interchannel Math Use

The following example uses a program to scan two lists of 16 thermocouple measurements every 10 minutes for 2 hours, and calculate the average of each group of 8 using math channels.

Program	Explanation
!DISP ENAB	
ENTL TEMP1; 101:CJT; 101-116:TEMP; 020; 021	 Junction temperature on multiplexer is measured before each scan of 16 thermocouples. 52-20 mux. Do math formula #20. (Take average of first 8.) Take average of second 8. After the first pass, there would be 19 data points in memory: One CJT, 16 T.C. measurements, and two averages of eight.
ENTL TEMP2; 201:CJT; 201-216:TEMP:J; 022; 023	The second channel list. J thermocouple specified. (Type K is default.)

MATH 20;
(CH101#2 + CH102 + CH103 + CH104 + CH105 + CH106 + CH107 + CH108)/8;
TAV1

MATH 21;
(CH109 + CH110 + CH111 + CH112 + CH113 + CH114 + CH115 + CH115)/8;
TAV2

MATH 22;
(CH201#2 + CH202 + CH203 + CH204 + CH205 + CH206 + CH207 + CH208)/8;
TAV3

MATH 23;
(CH209 + CH210 + CH211 + CH212 + CH213 + CH214 + CH215 + CH216)/8;
TAV4

Example 5-5. Interchannel Math Use (Continued)

Program	Explanation
ENTP TEMPS;	Program name for entry into memory is "TEMPS". (The unit will append a ".P" once in memory.
ASAP;	Start condition: As soon as possible.
CALL:TEMP1.L;	A channel list call. Note it is now referred to as "TEMP1.L".
CALL:TEMP2.L;	The second channel list call.
TIME:00:00:10:00;	Scan interval: 10 minutes. The time from a start of the first list to the time when the first list begins to be scanned again is 10 minutes.
SCAN:12;	Stop condition: After 12 scans through the program's channel lists listing.
STOP	Action upon completing program: stop. (Don't call another program or channel list.)
RUN TEMPS.P	

5.4 PROGRAMMING STRUCTURE AND SYNTAX DELIMITERS

This section will describe the Models 51 and 52 remote command structure common to both RS-232-C and IEEE-488 operation. If a command is unique to RS-232-C or IEEE-488, it is noted in that command's paragraph. Table 5-1 defines the syntax used with the commands. Table 5-2 summarizes the commands.

Table 5-1. Remote Structure, and Syntax Delimiters

Term	Definition
Commands	Commands are recognized by the unit (over RS-232-C and GPIB). A command can stand by itself (an action), contain an argument, or contain one or more subcommands and arguments (command string).
Subcommand	The subcommand is part of a string headed by a command. Some subcommands are implied, arguments for implied subcommands must be entered in correct order.
Arguments	An mnemonic or numeric entry following a command. A step down in hierarchy.
Subargument	A lower level entry under an argument.
:	A colon, a delimiter, separates a command from its argument and an argument from its subargument. Shows a step down of hierarchy. (Example: CH2:vac:3)
,	A comma, a delimiter, separates items of equal hierarchical level. (Example: R232 RTON,BAUD:3)
;	A semicolon, a delimiter, placed at the end of a line indicates the command sequence continues on the next line. The first time a semicolon is used in a command, it also indicates a deeper level of hierarchy. (Example: ENTL and ENTP commands.)
space	Used between some commands and their arguments. (Examples: RUN program. RCL ALLD. GOTO LLO.)
CR	A carriage return enters the current line of text. Prior to the carriage return, text may be edited. (A carriage return alone also causes a running channel list to stop.)

Blank lines are not permitted inside a channel list or program.

It is optional whether or not you follow the carriage return with a line feed. Since the unit does not send a leading line feed ahead of any response or data, it's recommended you set up for auto line feed after your carriage return. This will prevent the Model 51 or 52 from writing over the last line on your screen.

Table 5-2. Remote Command Summary

Command	Description	Reference Paragraph	Local MENU/ Action
@	Places unit in received character echo mode (default condition)	5.7.1	—
Λ	Places unit in non-echo mode	5.7.2	—
!	Places the Model 52 in remote	5.7.3	—
ALRM	Create an alarm channel	5.7.4	ALARMS
BIN LOAD	Loads a channel list or program	5.7.5	—
BOUT	Transmits a named channel list or program	5.7.6	—
CAL	Calibrates a given channel, function, and range	5.7.7	Selecting CAL function mod.
DATA	Sets transmit and storage selections, by data type	5.7.8	DATA ROUTING
DATE	Sets the unit's date	5.7.9	TIME/DATE
DEL	Deletes a named channel list or program from the unit's memory	5.7.10	Find Name.L/P, then DELETE
DIR	Transmits the directory of existing channel lists and programs	5.7.11	—
DISP DIS	Disables the Model 52 display	5.7.12	DISPLAY MODE
DISP ENAB	Enables the Model 52 display	5.7.12	DISPLAY MODE
ENTL	Creates a channel list	5.7.13	CHANNEL LIST
ENTP	Creates a program	5.7.14	PROGRAM
GOTO FPOF	Disables front panel key execution	5.7.15	KEYBOARD LOCK
GOTO FPON	Enables front panel keys to function in parallel with remote commands	5.7.15	—
GOTO LLO	Locks out the front panel	5.7.15	KEYBOARD LOCK
GOTO LOCL	Returns to front panel control	5.7.15	Entering code
GPIB	Sets the IEEE-488 communication options	5.7.16	IEEE-488
INIT	Resets the unit (clears data memory, programs, and channel lists)	5.7.17	Power-on-Clear
MATH	Creates a math channel formula	5.7.18	MATH
MON	Sets the monitor mode conditions	5.7.19	MONITOR MODE
POFF	Shuts off the unit's power	5.7.20	Power Key
R232	Sets the RS-232-C communications options	5.7.21	RS-232-C
READ	Reads data from any entry in a currently running channel list	5.7.22	Scrolling
RCL	Displays, transmits, or clears data from memory	5.7.23	RECALL DATA
RUN	Runs an existing program or channel list	5.7.24	Find NAME.L/P select **R**
STAT	Sets line reject frequency and power save mode	5.7.25	UNIT STATUS
STOP	Terminates a running program	5.7.26	MENU key
TIME	Sets the unit's real time clock	5.7.27	TIME/DATE
TRAK	Sets tracking parameters	5.7.28	TRACKING
WR	Writes decimal value to an output channel	5.7.29	DMM, enter ch#, function, etc.
XMIT	Sets Data Transmission control; Sets Memory management technique	5.7.30	TRANSMIT/MEM
CNF?	Model 51 only. Tells options installed and software version	5.7.31	CONFIGURATION
DT?	Model 51 only. Tells date and time	5.7.32	Measuring ch. 9 in DMM mode
ID?	Model 51 only. Tells software version	5.7.33	CONFIGURATION
MEM?	Model 51 only. Tells amount of storage memory left	5.7.34	MEMORY STATUS

5.5 ERROR CODES

The following error strings can be returned by the Model 51 or 52

E1 Bad command or syntax
E2 Bad numeric entry
E3 Illegal channel number
E4 Name already exists
E5 Cannot find program or channel list
E6 Out of memory
E7 Program in process, must terminate before proceeding
E8 Channel number not present in list, or no new measurement available.

5.6 PROGRAMMING HINTS

The DISP ENAB command is useful for on-site debugging.

As with programming in any language, the component parts of a list or a program should be checked alone, and on-site, before attempting to run a large program all together. This is essential if the Model 51 or 52 will be communicating to an off-site (off-premises) location. For locations that have no AC power, lightweight, battery-powered computers are now on the market.

Timeouts can be shortened for the pretest. The manual DMM mode is useful for verifying test lead hookups, and individual setups. Measurements done in DMM mode are also sent out the RS-232 or GPIB port, assuming the appropriate menus are enabled. (RS-232 or GPIB, DATA ROUTING (XMIT-CH LISTS selected), and TRANSMIT/MEM (CONTIN selected). A printer or dumb terminal can be hooked up, using only two lines from the Model 52: TXD, and signal ground. All STOREs in the DATA routing menu could be unselected, so memory isn't loaded up with messy readings.

Note that there is a direct correlation between manually selecting something in a menu, and the remote instruction that accomplishes the same effect. If in doubt as to the effect on the status of a measurement setup or data path, the menu can be manually called up and examined. (Model 52 users.)

The unit gives no remote indication that it is in remote mode, other than that commands, channel lists, and programs run correctly. Once you are off-site, the Model 52 can give no clue as to remote status via the front panel. A typical problem for beginners is attempting to give the Model 52 a remote command when it has popped out of remote. If in doubt, send the "!". If the Model 52 was in the "off" state, all the first "!" will do is turn it on. (This is true only for RS-232, and only if the rear panel "AUTO PWR" switch is up.) So a second "!" will be required (wait the power-up delay — 1000 milliseconds is plenty.) The DIR (directory) command can be used to verify that the Model 52 is in remote. DIR causes "*END" to be returned, preceeded by the names of any channel lists or programs that are in memory.

If offsite, you have no way of knowing if someone came along to the Model 52 and pushed a button on the front panel. Since this would pop it out of remote, local keyboard lockout is highly recommended. The remote commands for remote versus local, and keyboard enabled or disabled, are under the GOTO command. For keyboard lockout, the command would be GOTO LLO. This, currently, doesn't lockout the POWER switch. However, if the display is disabled, the words "REMOTE" will appear in the middle of the Model 52 display.

If the Model 51 or 52 is turned off and then back on, the channel list or program is stopped, but is still in memory. After sending "!" (Model 52), it can be restarted using the RUN command. Since cycling the power always reenables the keyboard, you may want to lockout the keyboard again.

Software checking of (echoed) characters sent from a computer's program can be used to verify that the electrical link to the unit has integrity. "@" (ASCII 40 Hex) turns echo on (default condition); "^" (ASCII 5E Hex) turns echo off. When characters are being sent manually, echo mode is also recommended. The computer/terminal should have its echo off.

5.7 REMOTE PROGRAMMING COMMANDS

This section describes in detail the commands, subcommands, and arguments used by both the Model 51 and 52 in the remote mode. RS-232-C and IEEE-488 share most of these commands.

Each command description contains a description of the command's function, a listing and description of related arguments and subcommands, and examples.

At the start of the paragraph describing the command is a command syntax line giving the general form of the command, such as **DATA** <arg1,...argx>. The comma following arg1 indicates that the next argument is on the same hierarchical level as arg1. That is, if there were a second argument, called arg2, its relationship to DATA is the same as arg1's relationship to DATA. Arg2 is not an argument of arg1.

If in the general form of the command, there is an unknown number of arguments of the same hierarchical level, this is indicated by the three periods after the comma.

Any argument in these sideways carats <> is always required. Arguments in brackets [ ] are not required for correct syntax, but may be required to accomplish

additional functions in one command. Subarguments that are in brackets are also optional.

A carriage return is implicit after each command. The exceptions are **!**, **@**, and Λ, which require no carriage return. Also, in the case of **BIN LOAD**, which uses more than one carriage return, all are shown for clarity.

The unit will accept either upper or lower case letters in the command word.

NOTE

Data may be transmitted from the Model 52 in both the local and remote modes. But before the Model 52 will decode instructions from the RS-232-C or IEEE-488 interfaces, the unit must be placed in the remote mode.

5.7.1 @ — Echo Mode

@

The @ places the unit in received character echo mode. (Only RS-232.) A carriage return is not needed.

Echo of the computer or terminal should always be off.

5.7.2 Λ — Non-echo Mode

Λ

The Λ places the unit in non-echo mode. (Only RS-232.) A carriage return is not needed.

Echo of the computer or terminal should always be off.

5.7.3 ! — Going to Remote

!

The exclamation point places the Model 52 in the remote mode. The Model 52 does not recognize any commands until the unit is placed in the remote mode. Once an "!" is received, the Model 52 stays in the remote mode until a "GOTO LOCL" command is received, the Model 52's power is turned off, or a front panel key is pressed (GOTO LLO not enabled).

"!" is an action command; that is, no carriage return (CR)is needed.

The Model 51 does not need an exclamation point since it always powers up into the remote mode, and it never exits the remote mode.

5.7.4 ALRM — Creating an Alarm (Setting up a Setpoint or Window)

ALRM <number>;
<Alarm condition>[,modifier if any];
T1:<Threshold Value>[,T2:<Threshold Value>];
<Alarm response:subarg>...<,alarm response:subarg>
(or)
ALRM <number>;
CLR

The ALRM command string creates and defines an alarm. A Model 51 or 52 alarm is a setpoint (threshold) or "window" setup, coupled with some response-action that takes place if the data is outside (or inside) this limit.

Major uses of alarms are to change data logging parameters (by changing the channel list or program that is running), and to change control conditions. Specifically, the change in control often is by sending a bit or byte pattern to a digital output port (turns on or off relays, typically).

A straightforward use of an alarm is to have only abnormal (out of limits) data stored in memory, or transmitted to a remote location. (See the **DATA** command). Conversely, only "in limits" data could be stored or transmitted.

Another use of an alarm is to run a channel list that transmits an exception message to a remote operator. (The channel list has a **text** channel reading embedded, DATA XLST and XMIT CONT were previously sent to the unit, and the appropriate comm port (RS-232 or GPIB) was set up.) The text entry can be up to ten characters, for example: "COME QUICK", or "VALV7STUCK".

Alarm-label numbers range from 1 to 31. The alarm number links the alarm to a measurement. The measurement uses the function modifier ALRM. The measurement could be a measurement module reading, a math channel output, a time channel reading (HMS only), or a reading of a digital input (or present output) value.

One alarm can be attached to several different measurements. But a measurement (datum) can have only one alarm attached to it. To attach more alarms (for example, different levels of thresholds and response), the measurement must be repeated for each alarm. So, a channel list might measure the same thing four times in a row, but with different alarms attached each time.

Each alarm entry requires 34 bytes of memory, so clearing unused alarms is good practice. For other material on alarms, refer to table 5-5 under **ENTL**.

(Alarm Removal)

CLR	Clear alarm from memory

Alarm Conditions

LTE	X≤T1
GTE	X≥T1
IWIN	T1≤X≤T2 (Inside WINdow)
OWIN	X≤T1 OR T2≤X (Outside WINdow)

Alarm Condition Modifiers

LCH	Latched alarm-response — until current channel list is exited
UNEN	Disable alarm setup. There is no remote command to reenable an alarm.

Threshold Levels

T1:<value>	Threshold 1, decimal value
T2:<value>	Threshold 2, decimal value Threshold levels are decimal values, up to 5 digits. To change a threshold level, the alarm condition (e.g. LTE) must be entered first. This is true even though the alarm condition is unchanged.

Alarm Responses

TONE:	
LOW	Low frequency tone
MED	Medium frequency tone
HIGH	High frequency tone
WRBL	Warbled tone
PULS	Pulsed tone
30S	30 Second tone
RUN:<name>	Runs a channel list or program named NAME.L OR NAME.P.
XMIT:RD	Transmits the reading
XMIT:RDTM	Transmits the reading and time
XMIT:A#	Transmits the alarm number
XMIT:ALL	Transmits all channel list or alarm readings from then on until the current channel list is exited.
STO:RD	Stores the reading
STO:RDTM	Stores the reading and time
STO:A#	Stores the alarm number
STO:ALL	Stores all readings from then on, until the current channel list is exited
OUT:	Outputs a value on an output channel Format: OUT:<output channel>:<value> Examples: OUT:510:<a decimal value> OUT:51x:<1 or 0> (x is the bit-place, 1-8) OUT:590:<a decimal value>

Alarm Example 1

```
ALRM 1;
IWIN,LCH;
T1:12.34,T2:56.78;
TONE:HIGH,TONE:WRBL,OUT:710:11111110,RUN:A.L (CR)
```

This example creates alarm number 1. This alarm's condition is true when the reading is inside the window between 12.34 and 56.78. The alarm response is a high frequency warbled tone, a digital output from channel 7_{10}, and the channel list A.L starts. The digital output is low in the least significant bit place. This could be the control signal that turns on a relay to begin to bring the process back in limits. (Output is low to sink relay coil current.)

Alarm Example 2

```
ALRM 1;
CLR
```

This clears alarm #1 from memory.

Alarm Example 3	Comments
ENTL AIRCONDX; 1:TEMP:T,F,ALRM:02; 1:TEMP:T,F,ALRM:03	Sets up a channel list named AIRCONDX to measure and control temperature. Uses T-type thermocouple, and makes the temperature read in Fahrenheit. Also attaches alarms 02 and 03.
ALRM 2; GTE; T1:74.0; OUT:511:0	Alarm number 2. Turns on air-cooler at 74°. Alarm condition; greater than or equal to...74 degrees. (Measured by the AIRCONDX list.) Alarm response; Put a LO to bit-place one on the digital output port of the Digital I/O card in slot 5. This turns on the air-conditioning relay. (Relay coil connected between bit-place one (pin 25, OUT0) and an external D.C. supply.)
ALRM 3; LTE; T1:70.0; OUT:511:1	Alarm number 3. Alarm condition; less than or equal to...70 degrees. Alarm response; Put a HIGH to bit-place one on the digital output port of the Digital I/O card in slot 5. This turns off the air-conditioning.

If a heater was to come on at 62°, say, it would probably be controlled by its own output bit. If the output bit was bit-place two (OUT1) on the port, the alarm could look like

```
ALRM 4;
LTE;
62.0;
OUT:512:0
```

And the alarm to turn off the heater at 66° would look like

```
ALRM 5;
GTE;
66.0;
OUT:512:1
```

To attach the alarms to the channel list repeat the measurement as shown above.

5.7.5 **BIN LOAD** — Transferring a Channel List or Program to the Model 51 or 52

BIN LOAD;<cr>
<file><cr>

BIN LOAD command string loads into the Model 51 or 52 from a remote source a binary (ASCII hex) file, representing a channel list or program. This file would have been previously sent to a controller, to be saved, using the BOUT command.

The BIN LOAD command must be followed by a semicolon, a carriage return, and the ASCII hex file. The unit stops receiving the file when it receives a carriage return without a preceding semicolon. Sending a carriage return without a preceding semicolon terminates the transmission. It is optional to have the *END statement transmitted after the ASCII Hex string.

Use of a computer with terminal emulation/file transfer software is recommended.

BIN LOAD Example

```
BIN LOAD;<cr>
00,26,05,4C,49,53,54,00,00,00,00,00,02,01,FF,00;<cr>
04,20,20,7B,00,02,02,00,00,00,00,00,00,09,FF,01;<cr>
00,28,00,00,1B,00<cr>
*END<cr>
```

5.7.6 **BOUT** — Transferring a Channel List or Program from the Model 51 or 52

BOUT<NAME>.L (or)
BOUT<NAME>.P

The BOUT command string transmits from the Model 51 or 52 the named channel list or program as a binary (ASCII Hex) file. ".L" or ".P" indicate a channel list or program, respectively. "*END" signifies the end of the channel list or program. A remote controller can use the *END statement to recognize the end of a transmission.

This command is similar to manually selecting XMIT-BIN from either the Channel List's or Program's action menu; see paragraphs 4.6.5 and 4.7.6.

BOUT Example

```
BOUT LIST.L<cr>
00,26,05,4C,49,53,54,00,00,00,00,00,02,01,FF,00;<cr>
04,20,20,7B,00,02,02,00,00,00,00,00,00,09,FF,01;<cr>
00,28,00,00,1B,00<cr>
*END<cr>
```

5.7.7 **CAL** — Calibrating a Function and Range

CAL <ch:func,range>,CAL (or)
CAL <ch:func,range>,CAL0;

The order of command string entry must be channel number (prefix "CH" not required), function, and range. For a list of the function and range mnemonics, see ENTL (Enter Channel List). A semicolon (;) must terminate the CAL command string. The unit returns "CALD" when finished with calibration.

The CAL command string initiates calibration of a given channel, function, and range. CAL0 denotes that the offset on that range is to be nulled out. CAL denotes that the gain error on that range is to be compensated for. The compensating-constants that the microprocessor derives from this process will thereafter be stored in memory.

A reference signal within the range specified by the command must be applied to the input of the unit during the calibration step.

During the calibration process, the Model 51 or 52 assumes that the applied reference signal is of extreme accuracy. For example, it assumes that an uncorrected reference signal of 1.990 volts is really 2.0000 volts, and adjusts itself accordingly.

CAL Example

```
CAL CH1:VDC,300M,CAL;
CALD
```

CAL0 Example

```
CAL 1:VDC,30,CAL0;
CALD
```

5.7.8 **DATA** — Setting Storage and Transmit Modes

DATA <arg1,...argx>

In data logging, there are four combinations of what kind of data is to be stored in memory (disregarding which measurement channel it is on):

- — Store both normal (in limits) and abnormal (out of limits) data.
- — Don't store normal data. Store abnormal data.
- — Store normal data. Don't store abnormal data.
- — Don't store normal data, nor abnormal data.

The **DATA** command, in conjunction with alarms (**ALRM**, paragraph 5.7.4) and monitor lists (**MON**, paragraph 5.7.19), gives you these choices.

The DATA command controls which data, (generated by channel lists, channel lists in programs, or data that meets alarm conditions), is stored. It also selects which of these types of data is to be transmitted out the comm port. The task of the user is to determine when his data falls into which of the four categories above, and then construct channel lists, alarms, and programs so that the unit can sort the incomming measurements.

Each **DATA** string can include any of the first six arguments, or NONE by itself. The first three arguments listed below specify the types of data to be transmitted. The second three specify the types of data to be stored. One argument, NONE, disables the DATA options. Each DATA string must be on the same line. A new DATA string overrides any previous DATA strings.

The **DATA** command controls only data being presently (real time) acquired. (The commands **RCL** and **XMIT** (except for XMIT CONT) do not have real time control over data.)

Mnemonic	Description	Example
XLST	Transmits channel list data	DATA XLST
XPRG	Transmits program data	DATA XPRG
XALR	Transmits alarm data (alarms must be set up in advance)	DATA XALR
SLST	Stores channel list data	DATA SLST
SPRG	Stores program data	DATA SPRG
SALR	Stores alarm data	DATA SALR
NONE	Clears data routing, no data stored or transmitted	DATA NONE

About alarm data: An alarm's response (see **ALRM**) must be set to transmit, and the DATA command must be set to XALR, for transmission of data meeting that alarm's condition to happen. Likewise, the alarm's response must be set to store, and the DATA command set to SALR, for storage of data meeting a given alarm's condition to happen.

Note that there is a "choice" which does not appear in the table above. That is to use a monitor list. A monitor list will not store data even if SLST is selected. (A monitor list will, however, store data under alarm conditions, assuming SALR is selected.) A monitor list is subject to the transmit selections above. (See **MON**, paragraph 5.7.19.)

A monitor list is used in conjunction with the Model 51/52 program mode. For example, the channel list that takes the measurements you do want to store has to be embedded in a Model 51/52 program (**ENTP**). Neither the monitor list nor the data-storing channel list have to have out-of-limits data (no alarm has to be set up). The monitor list simply never stores data. The data-storing list can then be subject to the selections above.

Example

```
DATA XLST,SLST,XALR
```

The DATA command works in conjunction with the XMIT CONT command. (See XMIT.) These two commands affect the (local-operation) main menus called DATA ROUTING and TRANSMIT/MEM. For example, the remote command DATA XLST has the same effect as manually going into the main menu called DATA ROUTING, and on the left (transmit) side of the menu, CH LISTS is selected (enabled). Likewise, for transmission while a channel list or program is taking measurements, the local selection CONTIN must be made in the TRANSMIT/MEM menu (remote equivalent is XMIT CONT).

NOTE

The INIT command will reset these menus to no selection.

The command to recall stored measurement data from memory later is the **RCL** command (paragraph 5.7.23).

Appendix C summarizes most of the data storage options. Appendix C, items 1-4, deal in the present; I.E., a channel list or program has already started. It is not defined under what conditions the channel list was started (could be in a program).

5.7.9 **DATE** — Setting the Date

DATE mm/dd/yy

The DATE command string sets the Model 51 or 52's date. All digits must be present when setting the date including any leading zeros. The delimiter "/" is not necessary but may be included for readability. The delimiter " – " is also acceptable.

DATE Example

```
DATE 07/01/86<CR>
```

5.7.10 **DEL** — Deleting a Channel List or Program

DEL NAME.L (or)
DEL NAME.P

The DEL command deletes a channel list or program from memory. When naming the channel list or program, the name must be suffixed with ".L" or ".P".

The DEL command (as opposed to INIT) is the preferred way of clearing a channel list or program from memory, even if there is only one in memory. This is because INIT affects the setup menus.

DEL Example

```
DEL PROGRAM.P
```

5.7.11 **DIR** — Getting a Directory of Channel Lists and Programs

DIR

The DIR (directory) command lists the names of all programs and channel lists stored in the Model 51 or 52's memory. Channel lists terminate with ".L" and programs terminate with ".P". The statement "*END" terminates the directory listing.

Using the DIR command is one way to verify that the Model 52 is in remote mode. (The Model 52 will echo characters even when it is not in REMOTE mode — it just has to be on.)

DIR Example

```
DIR<CR>

PROGRAM P
LIST.L
*END
```

5.7.12 **DISP** — Enabling or Disabling the Local Display

DISP DIS (or)
DISP ENAB

The DISP DIS command disables the Model 52's front panel display. After sending this command, the screen will display "REMOTE". Turning "off" the display allows faster readings since the microprocessor does not have to update the display.

Enabling the display (DISP ENAB) shows the Model 52's current operation.

DISP Examples

```
DISP DIS

DISP ENAB
```

5.7.13 **ENTL** — Creating a Channel List (a "Measurement Setup")

ENTL SER:<name>; (or)
ENTL PAR:<name>; (or)
ENTL <name>;
[CH]<chn>:[function][:range(s)][,mod(s)][,disp(s)][:]
[additional entries]

Channel lists are the "measurement-setups" of the Model 51 or 52. The ENTL command string creates a channel list and enters it into the unit's memory. After the list in entered in memory, the unit adds ".L" to its name. Any reference to the list after that must include the ".L".

When the unit is "running" a **SER**ial channel list, measurements are being taken continuously (aside from short delays that may be attached ahead of measurements). The unit is sequencing through the channel list taking measurements in the order they are listed; I.E., when the unit gets through with one pass through the list , it goes back to the top of the list, and immediately starts another pass. In a **PAR**allel channel list, the channel list is again running continuously. However, in this case, all of the measurements are being taken in parallel (user-specified delays aside). Since some measurements in a list take longer than others, this means that the readings quickly get out of any kind of sequence. So, a serial list is required if readings are to be kept in a specific order. A parallel list will do the greatest number of total measurements in a given period.

If it is desired to log measurements, but not continuously, or other channel lists are to be run alternately, a **program** must also be set up. (See **ENTP**.)

Commas (,) separate function, range, and function modifier arguments that are on an equal hierarchy level. Colons (:) associate arguments and their subarguments (for example: RES:DBAR) — (a step down in hierarchy). "CH" preceding the channel number is unnecessary, but may be included for ease of reading. Semicolons (;) at the end of a line indicate that the command continues on the next line. A carriage return (CR), WITHOUT a preceding semicolon (;) accepts the new channel list. See Example 5-6 for an example of constructing a channel list using ENTL. If a channel list is running, it can be stopped by any command that changes a setup, or a carriage return alone.

The text channel 0 accepts text of up to 10 characters per entry; more than 10 characters are ignored. It can be used more than once in a list, with different entries. The text entry in a channel list fits the general form:

0:characters

A typical use is that an alarm (some process out of limits) calls the channel list containing the text message. When the channel list scans the text entry, the message is then displayed or transmitted to an operator. (Assuming transmit or display paths are set up.) Another use for a text entry is as a "header". If each channel list has a different text channel header, a remote operator instantly knows which of several channel lists is currently running.

Since a channel list is a measurement-setup, you would expect it to have a name, channel numbers, and the functions and ranges for each channel. But also, a delay, an alarm (threshold or window), or tracking (or all three) can be attached to a measurement as a function modifier. (See table 5-5.)

The ability of the Models 51 and 52 to make greater than/less than decisions on the data measured or read in (alarm — see **ALRM**, paragraph 5.7.4) is at the heart of most of the unit's control applications.

Digital I/O channel inputs and outputs in a channel list always begin with the channel card's slot number: 5, 6, 7, or 8. The next number after the slot number signifies whether it is a digital input (0), a digital output (1), or an analog output (9). The third number for a digital input or output identifies the format: byte-wide, or just one bit. (a 0 means byte-wide; a 1 through 8 signifies the bit-place of a single bit, with 1 being the least significant.) For example:

500	Means to input a byte. (This is similar to a **READ**, but a **READ** can't be embedded in a channel list.)
510 OUT:10	Means to output a byte. Ten (10) is the value that was specified in this case. The value (for decimal numbers) must be between 0 and 255. (This is similar to a **WR**ite, but a **WR**ite can't be embedded in a list.) A colon between the channel number and OUT is optional.
501	Means to read in the bit in bit-place 1.
511:OUT:1	Means to output a bit to bit-place 1; The bit value was specified as one (1) in this case.

In example 5-6, the line

```
810:DEC,OUT:213,INC;
```

has the display modifier DEC (decimal numbering system) ahead of the function modifier OUT. Channels 5 through 8 deviate from the usual order of function, function modifier, then display modifier. See figure 5-1.

A user-set value can also be sent to the analog output (DAC) from a channel list entry. This is useful as a chart recorder marker. For example:

690 OUT:255	Means to set the DAC to its maximum value. (This is not the same as **TRAK**ing, which allows the DAC to change values automatically in response to changing measurement readings.)

Function Modifiers (Mods) and Ranges may have more than one entry per channel measurement. Each multiple entry should be treated as a separate argument and be separated by commas.

Measurement Module Functions, Ranges, Display Modifiers (Disp), and Function Modifiers (Mods) arguments can occur in any order. However, one argument may depend on a preceeding argument, thus, it is best to enter the Function before selecting a Range.

Tables 5-3 through 5-12 list the Function, Range, Function Modifier (Mods), and Display Modifier (Disp) mnemonics, arguments, and subarguments.

"Channel group programming" is when a dash (–) is used to indicate that the channel information applies to all of the channel numbers between the first and last channels separated by the dash. This technique saves time when entering long channel lists. Channel group programming can be used on channels 1-4 and any of the subchannels (multiplexer would be used) on a measurement module. See the second line of example 5-6, or the fourth and ninth lines of example 5-5.

Example 5-6. Entering a Channel List, Remote Programming

Channel List	Explanation
ENTL SER:LIST;	The following list is to be called "LIST". The readings will be taken one at a time as opposed to parallel.
101-108:VAC:30,MAX,RES:DBAR:	On channels 101 through 108 (using a mux), measure volts ac on the 30 volt range; display the max reading; resolution type is digibar.
2:CJT,F;	On channel 2, measure the cold junction sensor's voltage; modify it to Fahrenheit form.

Example 5-6. Entering a Channel List, Remote Programming (Continued)

Channel List	Explanation
810:DEC,OUT:213,INC;	Channel 810 is a digital I/O card's 8-bit-wide output. Whatever number is sent to this port will also be displayed on the front panel in DECimal form. Send a starting value of 213 out. Each time the channel list cycles through this step, increment this "identification number" by one.
3:FREQ,10K,X100,SENS:300M;	On channel 3, measure freq. (ac coupling is assumed because it is not specified); use 10KHz range; multiply by 100 before displaying; sensitivity of the transition-detector is 300mV.
0:READINGS;	Text entry. A comment, heading or message displayed, stored, or transmitted.
1:DB,DBM,REF:11,DLY:47;	On channel 1 measure db (ac assumed as opposed to dc); use dBm reference impedance number 11 (600 ohms). Delay for 4.7 seconds before making this measurement.
9:HMS;	Measure hours, minutes, and seconds.
301:FREQ,SCAL:21,AVG:5;	On channel 301 measure frequency; scale it by formula #21; average this five times before it's displayed, stored or transmitted.
302:FREQ,CUPL:DC,SENS:TTL	On channel 302 measure frequency, with dc coupling, sensitivity is 0.8 and 2.0V (TTL thresholds).

Table 5-3. Channel List Functions, Remote Programming

Mnemonic	Function
Channels 1 through 4	
VDC	dc volts
VAC	ac volts
VADC	Volt ac + dc
TEMP	Temperature
OHM	Ohms
DB	dB
FREQ	Frequency
TINT	Time interval
PWTH	Pulse width
PER	Period
T1SH	Time interval one shot
P1SH	Pulse width one shot
CONT	Continuity
DBDC	dBdc
DIOD	Diode check
CJT	Cold junction temperature
EVNT	Event
LOG	Logic
ADC	dc amperes
AAC	ac amperes
AADC	ac + dc amperes

Table 5-3. Channel List Functions, Remote Programming (Continued)

Mnemonic	Function
WDC	dc watts
VAAC	ac + dc volt-amperes
VAAC	ac volt-amperes
Channel 0 Text Channel	
	A channel list reads a preset entry on that line in a list. Entries may be repeated with different text. Up to ten characters per entry. Example: 0:Textexampl
Channel 9	
MDHM	Month, Day, Hour, Minute
HNS	Hour, Minute, Second
MDY	Month, Day, Year
Channels 51x, 61x, 71x, 81x (Byte Output)	
OUT	Output a Value (0 to 255 if in decimal). For a byte-output, X is always 0. (Example: 510 OUT:B1 (B1, a display modifier, is in the hexadecimal numbering system. The numbering system is implicitly assumed to be hex if no other numbering system is specified.)

Table 5-3. Channel List Functions, Remote Programming (Continued)

Mnemonic	Function
Channels 51x, 61x, 71x, 81x (Bit Output)	
OUT	Output a 0 or 1 only (x signifies the bit-place). Example: 513 OUT:1 (Puts a 1 to bit-place 3)
Channels 50X, 60X, 70X, 80X (Byte Input)	
The mnemonic "IN" is not required or allowed. Input is inferred from the channel number's second digit (example 500) being zero. For a byte-input, X is always 0.	Inputs all 8 bits. Example: 500 ASC (ASC is a display modifier — ASCII)
Channels 50x, 60x, 70x, 80x (Bit Input)	
The mnemonic "IN" is not required or allowed. Input is inferred from the channel number's second digit (for example, 501) being zero.	Inputs a 0 or 1 only. Example: 503 BIT Inputs the level at bit-place 3

Table 5-4. Ranges, Remote Programming

Mnemonic	Range
dc, ac, and ac + dc Volts	
AUTO	Autorange
30M	30mV
300M	300mV
3	3V
30	30V
300	300V
dc, ac, and ac + dc Current	
AUTM	mA Autorange
30M	30mA
300M	300mA
AUTA	Amperes Autorange
3	3A
10	10A
Ohms	
AUTO	Autorange
30	30Ω
300	300Ω
3K	3kΩ
30K	30kΩ

Table 5-4. Ranges, Remote Programming (Continued)

Mnemonic	Range
300K	300kΩ
AUTM	Autorange Megohms
3M	3MΩ
30M	30Ω
300M	300MΩ
3G	3000MΩ
Frequency	
AUTO	Autorange
10	10Hz
100	100Hz
1K	1kHz
10K	10kHz
100K	100kHz
1M	1MHz
4M	4 + MHz
X10	X10 Scale
X100	X100 Scale
X1K	X1000 Scale
Pulse Width and Time Interval	
AUTO	Autorange
100M	100 ms
1	1000 ms (1s)
10	10s
100	100s
360	360s
Period	
AUTO	Autorange
100U	100 μs
1M	1000 μs (1ms)
10M	10 ms
100M	100 ms
1	1000 ms (1s)
Diode Check	
1M	1 mA
100U	100 μA
10U	10 μA
1U	1 μA
100N	100 nA
Temperature	
K	Type K (default)
J	Type J
E	Type E
T	Type T

Table 5-4. Ranges, Remote Programming (Continued)

Mnemonic	Range
ac VA*, ac + dc VA*, and dc Watts*	
30V	30 V
300V	300 V
300M	300 mA
3A	3 A
10A	10 A

*This function requires a voltage entry and a current entry. The function is entered as Function, Range1, Range2;

Table 5-5. Function Modifiers, Remote Programming

Mnemonic	Modifier
Standard	
DLY	Delay (DLY:number)
ALRM	Alarm (ALRM:number)
TRAK	Track (TRAK:number)

Virtually all measurements the unit can make can have all three of these modifiers. Text channel can have no modifiers. Time channel can have the DLY and ALRM modifiers.

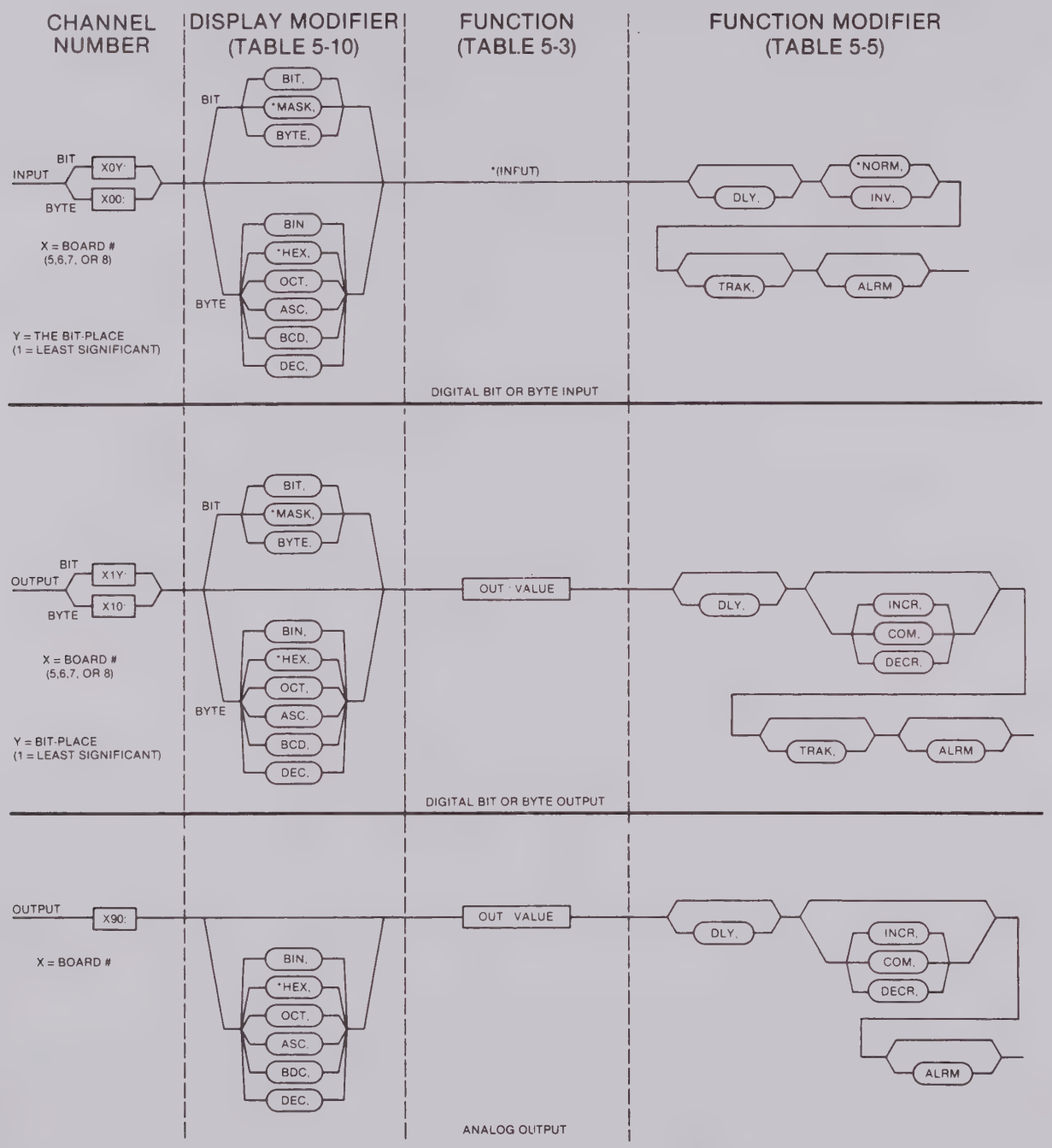
The delay number is the number representing the delay ahead of a measurement; it is user-specified in tenths of a second up to 25.5 seconds.

An alarm setup (ALRM function modifier) requires that the ALRM command be used separately. This can be done before or after the ENTL command string sets up the channel list. (See **ALRM**, paragraph 5.7.4.) The measurement, and the threshold or window it is judged against, are linked by the alarm number assigned by the user.

The tracking function modifier requires that the tracking parameters be set up separately. (See **TRAK**, paragraph 5.7.28.) This can be done before or after the ENTP command string sets up the channel list. Since different measurements may feed into different tracking setups, a particular tracking-setup and its measurement are linked by the user assigning a tracking output channel number. (For example, analog output channel **590**.)

Table 5-5. Function Modifiers, Remote Programming (Continued)

Mnemonic	Modifier
dc Volts	
Z10M	Input Impedance = 10 MΩ
Frequency and Period	
Entered as CUPL:mnemonic (CUPL:AC)	
SENS	Sensitivity (see Table 5-6, ac or dc
CUPL	ac or dc coupling (see Table 5-7a, ac/dc coupling)
Time Interval, Time Interval One Shot, Pulse Width, Pulse Width One Shot	
Entered as CUPL:mnemonic (CUPL:AC).	
SENS	Sensitivity (see Table 5-6, dc or ac coupling)
TRIG	Trigger (see Table 5-8)
CUPL	ac or dc coupling (see Table 5-7b, ac or dc coupling)
Temperature	
C	Degrees Celsius
F	Degrees Fahrenheit
KLV	Degrees Kelvin
dB	
Enter as DBM,REF:mnemonic.	
DBM	dBm
DBW	dBW
REF	Reference impedance (see Table 5-9, dBW or dBm).
Logic	
SENS	dc sensitivity (see Table 5-6, dc coupling)
NORM	Normal logic
INV	Inverted logic
Cold Junction Temperature	
C	Degrees Celsius
F	Degrees Fahrenheit
Channels 50x – 80x (Bit or Byte Input)	
NORM	Normal logic, noninverted (default)
INV	Inverted logic
Channels 51x – 81x (Bit or Byte Output)	
INC	Increment output value
DECR	Decrement output value
COM	Complement output value



NOTES:
1. Boxed entries are required.
2. Circled parameters may be bypassed.
3. * = Default selection.
4. Colon after channel number is optional.
5. Use no comma after last function modifier.
6. Function modifiers are shown in the order they will be performed.

Figure 5-1. Digital I/O Syntax for Remote Channel List Entry

Table 5-6. Sensitivity, Remote Programming

Mnemonic	Sensitivity
ac Coupling	
Enter as SENS:mnemonic (SENS:3M).	
3M	3 mV
30M	30 mV
300M	300 mV
3	3 V
30	30 V
dc	
Enter as SENS:TTL	
TTL	TTL
CM5	CMOS 5
CM12	CMOS 12
40M	±40 mV
400M	±0.4 V
80	+80 V

Table 5-7a. Coupling, Remote Programming

Mnemonic	Coupling
ac or dc	
Entered as CUPL:mnemonic (CUPL:AC)	
AC	ac coupling
DC	dc coupling

Table 5-7b. Coupling, Remote Programming

Mnemonic	Coupling
ac or dc	
Entered as CUPL:mnemonic, mnemonic (CUPL:DC,POS)	
AC	ac coupling
DC	dc coupling
POS	Positive edge triggering
NEG	Negative edge triggering

Table 5-8. Trigger Delay, Remote Programming

Mnemonic	Delay
Trigger Delay	
Enter as TRIG:mnemonic (TRIG:INDF).	
INDF	Indefinite delay
20	20 second delay
2	2 second delay
200M	2 ms delay

Table 5-9. Reference Impedance, Remote Programming

Mnemonic	Impedance
dBW	
Enter as DBW,REF:mnemonic.	
1	16Ω
2	8Ω
3	4Ω
4	2Ω
dBm	
Enter as DBM,REF:mnemonic.	
5	1200Ω
6	1000Ω
7	900Ω relative to noise @ −90 dB
8	900Ω
9	800Ω
10	600Ω relative to noise @ −90 dB
11	600Ω
12	500Ω
13	300Ω
14	250Ω
15	150Ω
16	135Ω
17	125Ω
18	110Ω
19	93Ω
20	90Ω
21	75Ω
22	50Ω

Table 5-10. Display Modifiers, Remote Programming

Mnemonic	Modifier
Channels 1 – 4	
SCAL	Scaled reading — SCAL:(math channel number). See also: MATH
MIN	Minimum reading.
MAX	Maximum reading.
RES	Resolution — see Resolution.
AVG	Average of readings — AVG:(number of readings averaged).
DLTA	Delta — see Delta.
Channels 500 — 800 (Byte Input) and Channels 510 — 810 (Byte Output)	
BIN	Binary number.
HEX	Hexadecimal number.
OCT	Octal number.
ASC	ASCII character.
BCD	Binary Coded Decimal number.
DEC	Decimal number.
Channels 50x — 80x (Bit Input) and Channels 51x — 81x (Bit Output)	
BIT	Individual bit.
MASK	Individual bit with rest of byte masked out.
BYTE	Entire byte.

Table 5-11. Resolution, Remote Programming

Mnemonic	Resolution
Resolution	
Enter as RES:mnemonic.	
LOW	Low resolution — RES:LOW
MED	Medium resolution — RES:MED
HIGH	High resolution — RES:HIGH
BAR	Bargraph
DBAR	High resolution bargraph

Table 5-12. Delta, Remote Programming

Mnemonic	Resolution
Delta	
Enter as DLTA:mnemonic (DLTA:NUM:1.5).	
RDG	Delta reading relative to a reading.
%RDG	% delta reading relative to a reading.
NUM	Delta reading relative to a user entered number.
%NUM	% delta reading relative to a user entered number.

5.7.14 **ENTP** — Creating a Model 52 Program (Does Things On-Condition)

ENTP <name>;
<start condition>;
<ch.listname.L>[:repeat count];
...other channel list calls;
<interval between scans>;
<stop condition>;
<termination action>

The ENTer Program (ENTP) command begins the entry of a new Model 51 or 52 program. ".P" is added to the program name after entry in memory. Any reference to the program must include the ".P". The ".P" should not be suffixed when entering the name — this will make the program inaccessible by remote operation.

Channel lists are scanned in the order they are listed. A program is often created around a channel list or lists in order to set conditions on when (in time, for example) the channel list is to start taking its measurements; the program could also keep track of how many passes it makes through the program, and stop the data logging after a predetermined number. (Start and stop conditions are further explained in tables 5-13 and 5-16.)

See also: **MON**.

The program sequence must in the following order.

1. Program Name. Example: ENTP TESTPROG;
2. Start Condition (Table 5-13).
3. Channel List Call or Calls (Table 5-14).
4. Scan Interval (Table 5-15).
5. Stop Condition (Table 5-16).
6. Termination Action (Table 5-17).

The unit expects the items to be entered in this order. Thus, most commands except "CALL" are assumed, only arguments and subarguments are entered. Example: "TERM:STOP" is not needed. Just use "STOP".

Example 5-7 demonstrates how to construct a program using ENTP. Also see Example 5-6.

While a channel list call is necessary to take a reading, some programs will not require the call. For example: Readings were taken previously, stored, and displayed. Later, an associate decides a print out would be nice. You won't be there tomorrow when he brings the printer. So you send the Model 51 or 52 the XMIT ENDP command. This makes all stored readings be transmitted at the end of any program. Next you create a dummy program that starts (and ends) at 10:00 a.m. tomorrow. The termination action of this dummy program is STOP. When the dummy program stops, the readings in memory will be transmitted to his printer, that he has plugged into the unit by 10:00 a.m.

Table 5-13. Start Condition

Mnemonic	Condition	Example
DLTA	Delta time (Δt) (dd:hh:mm)	DLTA:00:01:00;
RLT	Real time Clock (dd:hh:mm)	RLT:00:16:00;
HTRG	High level trigger (Logic **1**) on channel number 5ox — 8ox or EXT 1 — 4	HTRG:503;
LTRG	Low level trigger (Logic **0**) on channel number 5ox — 8ox or EXT 1 — 4	LTRG:1;
ASAP	As soon as possible	ASAP;

HTRG and LTRG require a Digital I/O card.

Table 5-14. Channel List Calls

Mnemonic	Description	Example
CALL	The argument(s) are the names of the list(s) to be scanned by the program (CALL:Name.L:n;) n = number of channel list scans (n = 1 will run the list once per program scan). n may be 1 – 99. (99 is the code for continuous scanning of the list. With n = 99, the program would never get to a second list in the program. (See also: SCAN, in table 5-16.)	CALL:TEST.L:3;
	When entering several channel lists, use a comma (,) as a separator	CALL:TEST.L:3,VLT.L:2;

Table 5-15. Scan Interval

Mnemonic	Interval	Example
CONT	Continuously scans the channel lists	CONT;
TIME	Sets the scan time: from the start of one pass through the program's channel lists listing to the start of the next pass through the program's channel lists listing. (TIME:dd:hh:mm:ss)	TIME:00:01:00:00;

Table 5-16. Stop Condition

Mnemonic	Condition	Example
DLTA	Delta time (Δt) (dd:hh:mm) from program start	DLTA:00:20:00;
RLT	Real time clock (dd:hh:mm)	RLT:01:16:00;
HTRG	High level trigger (logic **1**) on channel number 5ox — 8ox or EXT 1 – 4	HTRG:503;
LTRG	Low level trigger (logic **0**) on channel number 5ox — 8ox or EXT 1 – 4	LTRG:1;
SCAN	Set number of scans (0 – 9999)	SCAN:18;

Stop condition DLTA specifies an elapsed time from the moment the program starts. SCAN refers to the number of scans the program makes through itself. Specifying 9999 is the code to make the program run an infinite number of scans. (Unless stopped by the **STOP** command, paragraph 5.7.26.) Specifying a scan number of 0 is acceptable — this makes a "dummy program". HTRG and LTRG require a Digital I/O card.

Table 5-17. Termination Action

Mnemonic	Condition	Example
STOP	Program stops when it is completed	
RUN	Runs a program or channel list when first program ends	RUN:TEST.L

Example 5-7. Entering a Program Using ENTP

Program	Comments
ENTP TESTPROG;	Name of the program is "TESTPROG"
RLT:14:00:00;	Start when the clock equals 14:00:00
CALL:LIST.L:23,SECLIST.L:48,ABC.L;	Run LIST.L 23 times. Run SECLIST.L 48 times. Run ABC.L one time.
CALL:TEMP.L:3;	Run TEMP.L 3 times.
CONT;	The scan interval (interval between scans) is continuous — meaning no interval between scans.
SCAN:2134;	The number of scans through the program called TESTPROG is to be 2134 times.
RUN:NEXTPROG.P	After doing TESTPROG 2134 times, run the program called NEXTPROG.P.

5.7.15 **GOTO** — Changing Mode (Front Panel vs. Remote Commands)

GOTO <mnemonic>

The GOTO command changes the remote operating mode. Only one mnemonic may follow the GOTO command and must be separated by a space. There are no arguments.

Mnemonic	Comment
GOTO LLO	Local Lockout locks out front panel key control. Only turning **Power** off and on again or sending GOTO LOCL or INIT will override local lockout.
GOTO LOCL	Local returns to the local (front panel control) mode when in the remote mode. Running programs are terminated, the display is enabled, and the Model 52 displays the main menu. All remote commands are ignored until another "!" command is sent.
GOTO FPOF	Front Panel Off causes any front panel input to automatically generate a GOTO LOCL command, (providing the Model 52 has not received a local lockout GOTO LLO). This is the remote default mode.
GOTO FPON	Front Panel On enables the front panel key to function in parallel with the remote commands. This enables the user to RUN a list from remote, and use the ▲ ▼ cursor keys to scroll the list or change the monitor mode. With FPON the unit behaves similarly to the local mode.

GOTO Example

```
GOTO LLO
```

5.7.16 **GPIB** — Setting IEEE-488 Options

GPIB <arg1>[,arg2:subarg] (or)
GPIB <arg2:subarg>[,arg1]

The GPIB command string sets the unit's GPIB (IEEE-488) communication options. The arguments can be entered in either order. The GPIB address may be any number from 1 to 31. The default (INIT) value is set by the dip switches on the GPIB plug in board. Coming from the factory, the default value is 9. Argument mnemonics are given in Table 5-18.

Table 5-18. GPIB Mnemonics

Mnemonics	Description	Example
Argument1		
RON	Turns on GPIB receive only	GPIB RON;
TON	Turns on GPIB transmit only	GPIB TON;
RTON	Turns on GPIB receive and transmit	GPIB RTON;
OFF	Turns off GPIB receive and transmit	GPIB OFF;
Argument2		
ADDR	Sets the GPIB address (ADDR:address number)	GPIB ADDR:9;

GPIB Example

```
GPIB RTON,ADDR:11<CR>
```

5.7.17 **INIT** — Resetting the Model 51 or 52

INIT

The INIT (initialize) command immediately resets the unit, clearing all memory, erasing all programs, channel lists, and stored data. It places the Model 52 in the local mode. INIT also resets menu selections to their default values.

INIT accomplishes the same as a local power-on-clear.

INIT Example

```
INIT<CR>
```

5.7.18 **MATH** — Creating a Math Formula

MATH <number>;

The MATH command string sets up a user-defined formula. Up to 99 formulas may be defined. The math formula can be used as a channel number in a list, or to scale a reading. The math formula is entered in the same order as in a front panel formula entry (see paragraphs 4.3.7 and 4.5.8 if needed). Math entries occupy a variable amount of storage: from 13 to 132 bytes. Deleting unused math channels saves memory. Math formulas are deleted by sending the command **MATH** followed only by the formula number to be deleted. Math functions usable in formulas are given in Table 5-19.

Table 5-19. Math Functions

Function	Description	Example
+	Plus (add)	MATH 12;(CH2 + 3.14);
–	Minus (subtract) or negtive number	MATH 12;(CH2-0.5);
*	Multiply	MATH 12;(CH2*CH1:07);
/	Divide	MATH 12;(CH2/2);
(	Bracket	(CH1*CH2)/((2 + CH3)*4);
)	Bracket	MATH 12;(CH2/CH1);
X	Value of current reading; use only for scaling	MATH 12;(X*2); See text below.
SQRT	Square root	MATH 12;(SQRTCH1);
Constants	Numeric entries (5 decimal places maximum)	See 4-20 mA example below Math 12;(CH4:01*3.1416);
Channel Numbers	Channel numbers must be preceded by CH	MATH 12;(CH2/CH1);
#	Identifies a specific entry of a channel number	MATH 12;(CH2/CH1#3);
Entry Number Example:		2_{FP} °C 1_{FP} Vac 1_{FP} Hz
	CH1#3 refers to this third channel 1 entry --->	1_{FP} ms

A math function may contain up to 132 characters. Up to 20 levels of parentheses may be used. Floating point values are truncated to 5 decimal places. Fractional decimals must be prefaced with 0. (0.1234) No spaces are permitted in the formula. Subchannels are entered as CH1:07 (CH is optional, : is required). The math channel can be labled with a name containing up to four characters.

Math formulas may be used in two distinct ways:

— inter-channel calculations, and
— scaling.

Example 5-8 takes the average of three measurements using an interchannel calculation.

Example 5-8. Averaging Using an Interchannel Calculation

Format	Comments
MATH 12; (CH1 + CH2 + CH3)/3; AVG3<CR>	Math 12 is the 12th math formula. In a list it will be referred to as channel 012, the 0 representing "math channel". Channel 012 can be called in a list, and its calculated value can be stored, displayed, or transmitted.
ENTL AVERAGE; 1:VDC; 2:VDC; 3:VDC; 012<CR>	This list, when run, would display whatever the first three channels measured, and the output of the math channel; for example: 1_{FP} 1.0000 Vdc 2_{FP} 2.0000 Vdc 3_{FP} 3.0000 Vdc 0_{12} 2.0000 AVG3

A math channel used for calculations on more than one entry may be used only in a list which includes the entries referred to:

Example

Right		Wrong	
1_{FP}	Vac	1_{FP}	Vac
2_{FP}	Hz	3_{FP}	Hz
0_{42}	CALC	0_{42}M-ER R	CALC

(042 = CH1*SQRTCH**2**)

Scaling

To use a math channel for scaling (for example mX + b), a formula containing the variable X is created. This formula becomes a display modifier by taking the current reading from a measurement entry, performing the operation, and displaying, storing, or transmitting the calculated value. The unscaled reading is not displayed, stored, or transmitted.

Scaling Example 1:

To square a voltage reading, and display the result, with the label "VSQR", use:

```
Math 29;
X*X;
VSQR<cr>
ENTL VOLTSQ;
1:VDC,3,SCAL:29<cr>
```

RUN VOLTSQ.L would display:

1_{FP} 4.0000 VSQR if X = 2.

Note that the **SCAL** modifier implies **math**, so **0** is not needed ahead of the **29**. This is different from the standalone math channel entry **012** in the averaging example above. Also, the standalone 012 entry fits the general form: 0xx. This distinguishes it from a text entry in a channel list which has a colon : right after the 0: — as in **0:Texample**. (See paragraph 5.7.3 **ENTL** for more on a text entry.)

Scaling Example 2:

A common use of a math channel for scaling is in displaying a 4 to 20 mA measurement as 0 to 100 psig (pounds per square inch). The following math function performs this operation:

```
MATH 04;
(X-0.0004)*6250;
PSIG<CR>
```

and is used in the following list. (Note that the same math function may be used to scale multiple channels.)

```
ENTL PSI;
1:Adc,30M,SCAL:04;
2:Adc,30M,SCAL:04
```

RUN PSI.L gives a display such as:

1_{FP} 50 PSIG
2_{FP} 27 PSIG

5.7.19 **MON** — Setting the (Program) Monitor Mode

MON <arg>

The MON command string sets the Monitor Mode conditions. The Monitor Mode determines the unit's operation between channel list scans in a program. Only one of the three modes can be operational at one time.

Argument mnemonics are given in Table 5-20.

Table 5-20. Monitor Mode Mnemonics

Mnemonics	Description	Example
OFF	Powers down the Model 51 or 52 between scans in a program	MON OFF
TTNS	Displays on the Model 52's screen the time to the next scan (display must be enabled:DISP ENAB)	MON TTNS
LST	A monitor list will be run in between program scans	MON LST:NAME.L

Saving Battery Power

The OFF mnemonic selection basically turns off the whole unit, with the exception of the clock, in between scans through a program's channel list or lists. This lets battery power be conserved if the unit does not have to log data continuously. Another case where it may be useful is when the unit is the "controller" in a control loop: It need only "power up" every ten minutes (for example) long enough to make a decision (see **ALRM**), and then power down again. The relays that the output bits on the Digital I/O control can be wired as flip-flops

so they remember their state even when the unit is powered down. Or, relays that are mechanically latching are on the market.

The unit may be in the powered-down state, and you (in a remote location) decide you want to get some data ahead of schedule. Assuming the **Auto Pwr** switch on the back of the unit is up, the first character you send it over RS-232 will power it up. But then, the unit will decide it is in a power down period, and power itself down within a couple of seconds. To prevent this, send a **STOP** command soon after the **!**. This will make the unit exit the program, and go to the main menu. Since it never runs the program it never enters the scan interval, so it doesn't power down. Then you can run a channel list to get some current measurements. Note that exiting a program will reset the scan interval "timer". (If it is stored data you want, use the **RCL** command.)

The Monitor List

A monitor list is useful when it is desired to constantly monitor (display or transmit) some variable, but only store a reading once in a while. The channel list that is to be the monitor list must be created separately (see **ENTL** command). Even though it is created separately, the MON LST command designates it as the monitor list. The monitor list will transmit any data it measures, if transmission from channel lists is enabled (**DATA** command). Unlike a normal channel list, the monitor list (without an alarm) will not store any of its measurements in memory. This is true even if storage from channel lists is enabled (**DATA** command).

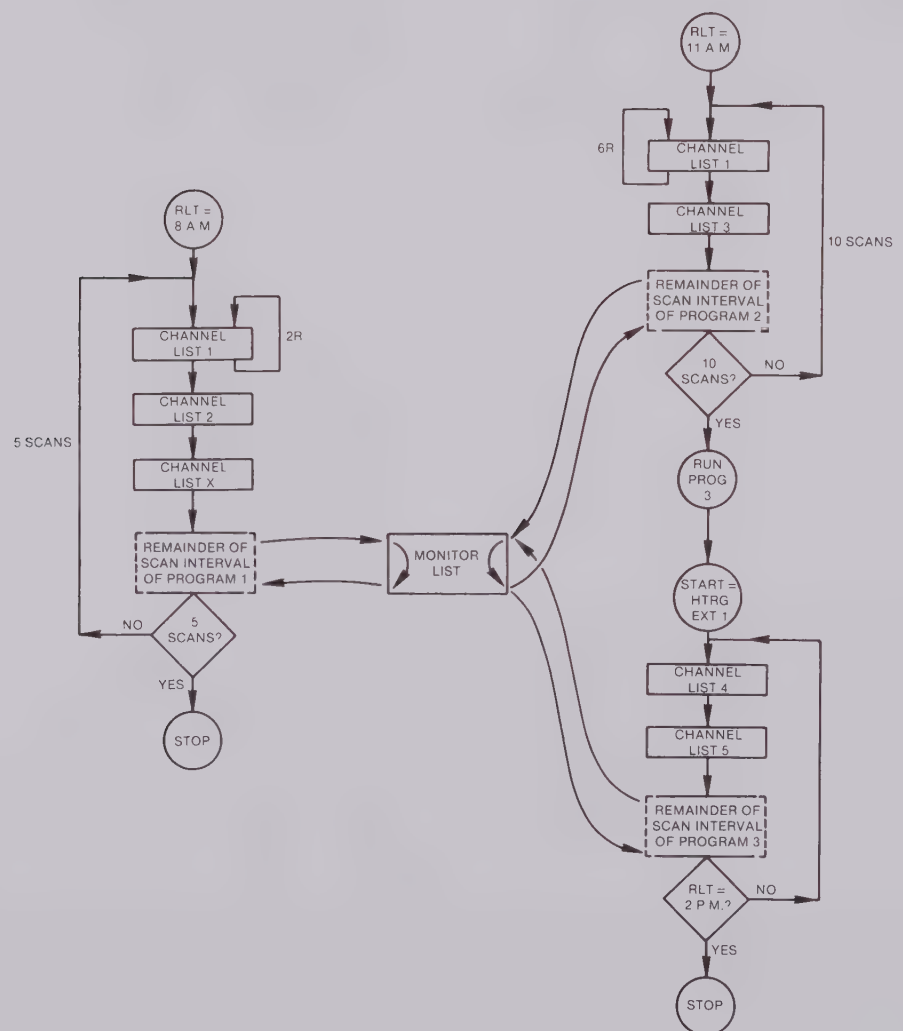


Figure 5-2. Monitor Channel List Operation

Monitor list operation is diagrammed in figure 5-2. (Refer to the **ENTP** command, and table 5-15, if necessary, for information on intervals between channel list scans in a program.) In between the scans of the data-storing list, the program would normally be idle. A monitor list, if so designated by the **MON** command, becomes active during these periods.

A monitor list is not attached to a specific program. Therefore, the monitor list has no number the way an alarm's <number> attaches it to a channel list reading (function modifier). The one monitor list could operate during the scan intervals of several unrelated programs.

As mentioned in section 3, channel lists actually do the work of taking measurements. It may be that it is appropriate to log data (frequency stability of a VCO, for example) only as long as ambient temperature is within a certain benign range (but we don't want to fill up memory with temperature readings). The program could be set up to pause for two minutes between scans ("scan interval") through its channel list that measures frequency. During these pauses, the unit is to monitor the ambient temperature. The vehicle that does this is the monitor (channel) list. The monitor list is set to measure cold junctcn temperature (CJT)...

A monitor list is useful when you want to keep track of some variable (often environmental), but don't want to log it. This adds flexibility to the DATA command, as to which channel lists will have their data stored.

Example

MON LST:LIST.L

5.7.20 **POFF** — Shutting Off Main Power

POFF

The POFF command shuts off the unit's power. The first character sent over RS-232-C turns the power on, if the rear panel switch S1 is on (up). See paragraph 2.3.9.

Example

POFF<CR>

5.7.21 **R232** — Setting RS-232 Options

R232 <arg1>[,arg2:subarg] (or)
R232 <arg2:subarg>[,arg1]

The R232 command string sets the Model 52's RS-232-C communication options. Arguments can be entered in either order.

Argument mnemonics are given in Table 5-21.

Table 5-21. RS-232 Communication Options

Mnemonics	Description	Example
Argument1		
RON	Go to RS-232 receive only mode	R232 RON;
TON	Go to RS-232 transmit only mode	R232 TON;
RTON	Go to RS-232 receive and transmit mode	R232 RTON;
OFF	Turn off RS-232 receive, CTS, and transmit (See note below)	R232 OFF;
CTS	Toggles CTS/DTR handshake status	R232 CTS;
Argument2		
BAUD	Sets RS-232 baud rate	R232 BAUD:3;

Note: Once **R232 OFF** is executed, only local resetting of the RS-232 menu, or GPIB use of the R232 command will re-enable RS-232 communication.

If receive and transmit are on, and transmit is wanted off, use **RON**. Any use of the first three argument1 type arguments not followed by ,CTS will turn off hardware handshaking. R232 CTS by itself will toggle hardward handshaking — not necessarily turn it on. To guarantee that CTS is left on, one of the first three arguments in table 5-21 should be used ahead of CTS. Use of BAUD does not affect CTS.

Echo (paragraph 5.7.1) requires that transmit be turned on.

Baud Rate Codes

Code	Baud Rate	Example
0	76.8k	R232 BAUD:0;
1	9600	R232 BAUD:1
2	1200	R232 BAUD:2
3	300	R232 BAUD:3

The rear panel dip switches set the default (INIT) baud rate. A local power on/clear will also cause these switches to be read. Setting the dip switches to the desired baud rate is strongly urged if off-site operation is contemplated.

Example

R232 TON,BAUD:1 Turns on transmit only, turns off CTS; sets baud rate to 9600.

R232 RTON,CTS Turns both receive and transmit on, toggles CTS back on.

5.7.22 **READ** — Reading Live Data On Demand

READ <ch>:[Entry#]

The READ command reads data from any currently running channel list. The command is followed by a channel number and an entry number. Valid channel numbers are 1, 2, 3, 4, 5, 6, 7, 8, 9, and 0 (including the text channel), plus subchannels. Entry number allows reading of a specific entry of a channel; valid numbers are 1 through 9. If an entry number is not used, the unit assumes the first entry.

For example, if a channel list consists of seven channel 2 measurements, selecting channel 2 seventh reading (READ CH2:7) reads the seventh measurement. Once a measurement has been read, the Model 51 or 52 will return an E8 code until another measurement is taken. (It assumes you don't want the same data point twice.) The "CH" ahead of the channel number is optional. A colon (:) must always follow the channel number entry. READing the data does not affect the operation of the channel list and will work regardless of the current setting of DATA or XMIT. The READ response is usually returned within 200ms. If a channel list is not running, or if you have just started running a list and the first piece of data is not yet ready, the unit returns an E8 error code.

The READ command is used when you want data sent only when you request it. READ can't be embedded in a Model 51 or 52 list or program. READ is sent by something remote that has intelligence (a controller program or a remote operator typing it in). See also: **XMIT**.

(For a digital I/O card, the opposite of a READ is a write. See **WR**, paragraph 5.7.29.)

Examples	Comments
READ 113:2	Reads the second entry of channel 1, subchannel 13.
READ CH1:	Reads the first entry of channel 1.
READ 700:	Reads all bits of digital input channel 7. The first zero in 700 signifies it is an input channel; the second zero signifies that all eight bits are to be read.
READ 802:	Reads the second bit of digital input channel 8. (Bits are numbered 1 through 8.)
READ 501:	Reads the least significant bit of input channel 5.
READ 608:	Reads the most significant bit of input channel 6.
READ 510:	Reads the current value of output channel 510. (Channel 510 could be tracking a signal, or could be incremented on each scan through a channel list. A READ is a way of finding out where you are.)

5.7.23 RCL — Stored Measurement Data: Displaying, Transmitting, or Clearing It

RCL <arg>

The RCL command (recall) is used after data has been accumulated in memory, often by a data logging setup.

The RCL command displays, clears, or transmits data from the unit's memory. Data can be recalled by channel number, (program) scan number, time, or alarm number, as it was automatically "tagged" with these attributes at the time it was stored.

Argument Mnemonics are given in Table 5-22.

Table 5-22. Recall Mnemonics

Mnemonic	Description	Example
CHNX	Transmits all data for the specified channel number. e.g. RCL CHNX:channel number	RCL CHNX:3
SCNX	Transmits all stored data beginning at a specified scan number. e.g. RCL SCNX:channel number.	RCL SCNX:3
TIMX	Transmits all stored data beginning at a specified time; e.g. RCL TIMX:time(hh:mm:ss).	RCL TIMX:16:00:00
ALMX	Transmits all stored data for a specified alarm number.	RCL ALMX:31
ALMX:0	Transmits all stored alarm data.	RCL ALMX:alarm number
ALLX	Transmits all stored data.	RCL ALLX
CHNC	Clears all data for a specified channel number. e.g. RCL CHNC:channel number.	RCL CHNC:2
SCNC	Clears all stored data beginning at a specified scan number; e.g. RCL SCNC:scan number.	RCL SCNC:5
TIMC	Clears all stored data beginning at a specified time; e.g. RCL TIMC:time(hh:mm:ss).	RCL TIMC:21:00:30
ALMC	Clears all stored data for a specified alarm number; e.g. RCL ALMC:alarm number	RCL ALMC:19
ALLC	Clears all stored data.	RCL ALLC
CHND	Displays all stored data for a specified channel number; e.g. RCL CHND:channel number.	RCL CHND:2
SCND	Displays all stored data beginning at a specified scan number; e.g. RCL SCND:scan number.	RCL SCND:90
TIMD	Displays all stored data beginning at a specified time; e.g. RCL TIMD:(hh:mm:ss).	RCL TIMD:04:05:10
ALMD	Displays all stored data for a specified alarm number; e.g. RCL ALMD:alarm number.	RCL ALMD:21
ALLD	Displays all data.	RCL ALLD

RCL ALLC is the fastest way to clear the memory because clearing by a group requires sorting and reorganizing the memory which slows down the process.

The **DATA** command (paragraph 5.7.8) has selections for storing data from channel lists, programs (data acquired by channel lists running inside programs), and data stored under alarm condition. When a channel list measurement has an alarm (setpoint or window) attached, when the alarm is "true", the data is stored by alarm number. With software version 4.23G and later, data stored as alarm data is also recallable by channel number.

Example

RCL CHNX:2

Note

*To display the data on the display of the Model 52, the **DISP ENAB** command must be used prior to the recall of the data to be displayed.*

5.7.24 **RUN** — Starting a Program or Channel List Running

RUN <channel list name>.L (or)
RUN <program name>.P

The RUN command selects and runs an existing channel list or program. A RUN command must specify the channel list with the ".L" suffix, and the program with the ".P" suffix. When a program is running, the STOP, GOTO LOCL, GOTO LLO, READ, and WR commands are accepted. All other commands cause an error message or no response.

See also: **STOP**

Example

RUN PROGRAM.P

5.7.25 **STAT** — Setting Line-Frequency Rejection and Power-Save Mode

STAT <line-frequency rejection>,[power save mode]

The STAT command allows selection of the line frequency rejection (50 or 60 Hz) and the power save mode. The STAT command must always be followed by the line rejection frequency and must always be on one line. Line-frequency rejection sets the appropriate integrate interval of the A to D converters on the measurement modules. This is so that any line-frequency interference riding on the signal to be converted is rejected. Default (**INIT**) selection: 60 Hz.

Power save off keeps power on to all channels when the chassis is on.

When power save is on, power to all measurement modules is off when in the main menu, and when a channel list is run, only those channels called for in the list are powered on. When Power-Save is on, it starts the channel list after a power on delay of approximately 2 seconds, but draws much less power.

For example, if channels 1 and 2 are in a list that is always running, they will always have power, even if there is a delay specified on one of the measurements. Channels 3 and 4 will be off.

If this channel list is part of a program that is not always running the list, even channels 1 and 2 will be off between calls to the list.

Line rejection frequency and power save mode mnemonics are given in Table 5-23.

Table 5-23. Frequency Rejection and Power Save Mnemonics

Mnemonic	Description	Example
60HZ	Sets 60Hz line rejection.	STAT 60HZ
50HZ	Sets 50Hz line rejection.	STAT 50HZ
PWRS	Power saver mode enabled.	STAT 60HZ,PWRS
	Absence of PWRS clears the power saver mode.	STAT 60HZ

5.7.26 **STOP** — Stopping a Program That Is Running

STOP

The STOP command terminates a running program. The unit does not accept any remote commands except **WR**, or **STOP**, while a program is running (Error code E7).

Example

STOP

(To exit a channel list, send any command that changes a setup, or a carriage return. The **READ** and **WR** commands don't change any setups.)

5.7.27 **TIME** — Setting the Real Time Clock

TIME<hh:mm:ss>

The TIME command string sets the unit's real time 24 hour clock. Enter time as hh:mm:ss with leading zeros (0); separating colons (:) are optional. All unentered digits are assumed to be zeros. See also: **DATE**.

Example

TIME16:30:22

5.7.28 **TRAK** — Setting Tracking Parameters

TRAK chan:<argl:subarg1>[arg2:subarg2][arg3]

The TRAK command string sets up the digital output and analog output tracking parameters, so that one or both of these outputs vary as a function of something being measured. (See also table 5-5, under **ENTP.**) The set of parameters of a tracking setup for a given output channel does not have an explicit "tracking-setup number" the way an alarm or math channel has a setup number. But it does have an implicit number — it's output channel number (510, for example). An output channel can have only one tracking setup at a time. The tracking setup is associated to a measurement the unit is making, by the function modifier TRAK. (See **ENTP** command, table 5-5).

Only one channel number may be entered per TRAK command. The zero (ZERO) and full scale (FSCL) must be entered before entering single ended (SE) or bipolar (BIP). The DAC increments are 10 millivolts per step. The D to A converter output range is zero volts (00000000) to + 2.55 volts (11111111), regardless of whether single ended or bipolar is specified.

The input function to the Digital I/O card must have a zero and a full scale value specified. The zero and full scale "tags" are attached to the **input** function, and not to the output of the DAC. This is because if a full scale value of 0.63 volts, for example, was specified for the **output** of the DAC, it would operate only over one-fourth of its range. This would give us less resolution — six bits instead of eight.

If single ended is specified, the value you specify as the "zero" of the input function causes the Digital I/O to output zero volts (00000000). But if bipolar is specified, the value you specify as the zero of the input function causes the Digital I/O to output 1.28 volts (10000000). 1.28 volts is midway between the endpoints of the DAC. Thus, if the input function should go below the value you specified as the input's zero, the output from the digital I/O card can follow this.

The one (1) after a channel number, as in 5**1**0, signifies **output**. The zero (0), as in 51**0**, signifies that all eight bits are to be controlled (the only resolution allowed).

The nine (9) after a channel number, as in 6**9**0, signifies that the output is analog; that is, the digital to analog converter is to be written to. Analog output resolution is always eight bits.

Argument mnemonics are given in Table 5-24.

Table 5-24. Tracking Mnemonics

Mnemonic	Description	Example
510	Digital output for channel 5	TRAK 510 ...
610	Digital output for channel 6	TRAK 610 ...
710	Digital output for channel 7	TRAK 710 ...
810	Digital output for channel 8	TRAK 810 ...
590	Analog output for channel 5	TRAK 590 ...
690	Analog output for channel 6	TRAK 690 ...
790	Analog output for channel 7	TRAK 790 ...
890	Analog output for channel 8	TRAK 890 ...
ZERO	Sets Zero level (ZERO:value)	TRAK 590:ZERO:2.5, ..
FSCL	Sets Full Scale level (FSCL:value)	TRAK 590:..... FSCL:5,...
SE	Selects Single Ended output	TRAK 590:ZERO:2.5,FSCL:4.5,SE;
BIP	Selects Bipolar output	TRAK 590:ZERO:2.5,FSCL:5,BIP;

Example1

A typical application of tracking is to derive an analog output for driving a chart recorder. For example, a 2.0 KHz to 7.3 KHz signal covers the range of interest. This range is to be converted to an analog voltage for a chart recorder.

At 2000 Hz the chart recorder is to get zero volts. At 7300 Hz the chart recorder is to get +2.55 volts. So the **TRAK** command is TRAK 590:ZERO:2000,FSCL:7300,SE

The function modifier TRAK, along with the number of the output channel that is supposed to track the reading, is also embedded in the channel list that measures the frequency:

```
ENTL CHART;
1:FREQ:10K,TRAK:590

RUN CHART.L
```

2.0 KHz measured on channel 1 will provide a zero-volts analog output from channel 5. Increasing frequency — up to 7.3 KHz, will linearly increase the analog output to 2.55 Vdc (full scale).

Example2

The ENTL entry

```
2:VDC:30,SCAL:89,TRAK:690
```

measures dc volts on channel 2, 30-volt range, and scales it by math formula 089 (the "0" is assumed — if you say "SCAL", it knows you're talking about math). Then it sends the output of the math channel to tracking channel 690, which in this case is the analog output. The output of the math channel (the display modifier) is what is displayed on the Model 52 display — not the original volts reading, and not the output of channel 690. The "TRAK:690" is considered a function modifier.

The TRAKing parameters would be set up separately.

Example3

```
TRAK510:ZERO:1.00,FSCL:6.00,BIP
```

Sets up the tracking for Digital I/O card number 5. If the input function is 1.00 volts (or ohms, or watts, etc.), the output from the Digital I/O card will be 10000000 (the digital equivalent of 1.28 volts from the DAC). If the input function is 6.00 volts, the output will be 11111111. And if the input function is −4.00 volts, the output will be 00000000.

5.7.29 WR — Writing a Decimal Value to an Output Channel

WR <ch:value>

The WR command allows a remote operator or computer to instantaneously write a decimal value directly to a digital or analog output channel. Valid channel numbers and values are given in Table 5-25.

Table 5-25. Write Channel Numbers and Allowed Decimal Values

Channel Number	Decimal Value	Example
5_{1x}, 6_{1x}, 7_{1x}, 8_{1x}	0 or 1	WR 518:1
5_{10}, 6_{10}, 7_{10}, 8_{10}	0 to 255	WR 610:32
5_{90}, 6_{90}, 7_{90}, 8_{90}	0 to 255	WR 890:126

Note: x denotes a bit-place; 1 to 8 is allowed.

This command functions in only two specific operating states:

1. The Model 51 or 52 is at the main menu (whether displayed or not). If in doubt, a carriage return will get it back to the main menu.
2. A list is running (within program is ok), and the main reading display is active (displayed or not). The only way the main reading display would not be active is if FPON has been enabled and MODS, FUNC, or similar local keys are in use.

The one (1) after a channel number, as in 5**1**0, signifies **output**. The zero (0) in the third place, as in 51**0**, signifies that all eight bits are to be controlled. A number other than zero (0) in the third place, as in 81**2**, signifies that just that bit-place is to be written to.

When the WR command is received, the selected channel output is immediately overwritten. If an individual bit is changed, only the specified bit is changed.

With the power off, all bits are high-Z. Power on places all outputs in the 1 state.

One application of the **WR** command is to generate a marker for a chart recorder. All zeroes could be written to the analog output. This would override the **TRAK**ing value until the time of the next **TRAK** output. Another application of the **WR** command is to remotely set or reset an output bit which initiates or stops a process or experiment being monitored by the unit.

Note that an output bit or byte can also be written by a channel list. To write from a channel list, the channel list entry would be

718 OUT:x

to write the value x (0 or 1) to the most significant bit (bit 8) of channel card number seven. See **ENTL**, paragraph 5.7.13.

(There is an input equivalent of **WR**. See **READ**.)

Examples

WR 710:255	Sets the digital output of channel 7 to all 1's.
WR 812:1	Sets the second bit of channel 8 to 1; the other seven bits are unchanged.

5.7.30 **XMIT** — Data Transmission Control and Memory Management

XMIT <arg1>[,subarg1][,arg2...]

The transmit mnemonics of the XMIT command act as filters that control WHEN data is sent out the remote port. If CONT is selected then the DATA command controls WHICH kind of data is sent out (e.g. DATA XLST) while readings are being taken.

The memory management mnemonics of the XMIT command (WRAP or FILL) determine how the limited data storage memory space is to be managed. They only have effect if some form of data storage is enabled (e.g. DATA SLST).

Mnemonics are given in Table 5-26.

Table 5-26. Transmit and Memory Control Mnemonics

Mnemonics	Comments
Transmit Mnemonics	
CONT	Transmits continuously from a running list or program. For the data to actually be sent, DATA XLST, DATA XALR or DATA XPRG must be executed as well. If data storage was enabled (see **DATA**), once memory is full, further storage will stop, but transmissions will continue.
MFUL	Transmits all stored data, when the unit's storage memory is filled. Setting of DATA command has no effect. The measurement process is suspended while the transmission is taking place. If WRAP is selected, transmission will occur only on the first memory fill.
ENDP	Transmits all stored data whenever a program finishes. Setting of DATA command has no effect. If the termination action of a program is to call a second program, the start of the second program will be delayed until the data transmission is completed.
Optional subargument for the above three transmit mnemonics:	
,CLR	Clears data after it is transmitted. Setting XMIT CONT,CLR has the effect of disabling data storage regardless of the DATA setting; any time a reading is transmitted, all stored data is deleted.
NONE	Clears any CONT or MFUL or ENDP selections. Also, sets memory management to the default "FILL".
	Note CONT, MFUL, and ENDP are mutually exclusive. Only the last one encountered on a line is processed.
Memory Management Mnemonics	
WRAP	Once memory is full, new data begins being stored in place of the earliest old data.
FILL	Once memory is full, no new measurements can be taken until one of the first three transmit mnemonics' actions is completed.

When memory gets full, anytime any kind of data is cleared, transmission is reenabled. (This may be by a real time transmit-and-CLR, or it may be done by using one of the clear selections of the RCL command.)

Examples:

XMIT ENDP,CLR	Transmit at the end of the program, clear the data block transmitted when done.
XMIT CONT	Transmit continuously data selected by DATA command (e.g. DATA XLST).
XMIT WRAP	Select WRAP memory management. Transmit selections are unchanged.
XMIT NONE,WRAP	Deselect any transmit mnemonics; select WRAP.
XMIT CONT,WRAP	Transmit readings as measurements are taken; select WRAP.
XMIT ENDP,FILL	At the conclusion of a program, transmit the data selected by the DATA command (XLST, XPRG, XALR). Select FILL.
XMIT MFUL,CLR,WRAP	The WRAP is superfluous since memory is cleared after each time the data is transmitted. (The situation is the same as if it was XMIT MFUL,CLR,FILL.)

5.7.31 CNF? — Requesting Configuration Information

CNF?

This command causes the software revision number and options installed information to be transmitted. Model 51 only. (Model 52 users can get the same information by manually looking at the CONFIGURATION menu contents — local operation).

5.7.32 DT? — Date and Time

DT?

This command causes the date and time to be returned. Model 51 only. (Model 52 users must use the main menu TIME/DATE in local.)

5.7.33 ID? — Software Version

ID?

This command causes the revision number of the software installed in the unit to be transmitted. Model 51 only. (Model 52 users must use the CONFIGURATION MENU in local.)

5.7.34 MEM? — Storage Memory Left

MEM?

This command causes the amount of data storage memory left ("bytes free") to be transmitted. Model 51 only. (Model 52 users must use the MEMORY STATUS menu in local.) MEM? does not work when a program or channel list is running.

5.8 RS-232-C INFORMATION SPECIFIC TO THIS UNIT

5.8.1 General

The Model 52 RS-232-C interface provides a serial communications link between the data multimeter and any other serial peripheral like a computer, modem, terminal, printer, etc.

If you are trying to get your link working for the first time, it may be helpful to refer to section 5.6, "Programming Hints".

Models 51 and 52 RS-232-C

Configuration	DCE or DTE (selectable by internal header)
Communication Mode	Full Duplex
Transmission Mode	Asynchronous
Baud Rate	300, 1200, 9600, and 76800
Data Format	1 Stop Bit 8 Data Bits No Parity
Handshaking	Hardware: CTS/DTR (menu enabled) Software: XON/XOFF
Connector	DB-25 (female)

The units use 8 data bits. There is no option as to number of data bits.

The Models 51 and 52 can be configured for either DTE (data terminal equipment) or DCE (data communication equipment). The configuration is selectable by an internal header; see paragraph 2.3.4, DCE/DTE Header. The Model 52 is shipped set up for DCE configuration.

5.8.2 Manually Setting the RS-232-C Options

The RS-232-C options can be set from the front panel.

1. Select RS-232-C from the main menu. Hint: press **Func**.

RS-232-C
<RECEIVE OFF>
<XMIT CTS/DTR>
<BAUD 9600▲ ▼

2. Select the options.

Item	Description
RECEIVE	Sets the Model 52 for RS-232-C receive.
XMIT	Sets the Model 52 for RS-232-C transmit.
OFF	Turns off RS-232-C receive and transmit.
CTS/DTR	Enable CTS handshaking. See paragraph 5.8.6. **Note:** Any use of the remote command R232 will disable CTS/DTR unless set at same time.
BAUD	Use the ▲ ▼ cursor keys to select the baud rate. 300 1200 9600 76800

Full-duplex permits simultaneous data transmission between a Model 52 and a controller. To both transmit and receive over the RS-232-C link, select both RECEIVE and XMIT.

To change the RS-232 options remotely, see paragraph 5.7.21.

The baud rate selection is retained between power-off's. The rear panel baud rate switches will be read only with a power-on clear (local) or an **INIT** (remote).

5.8.3 RS-232 Commands

Over the RS-232-C link the Model 52 recognizes all the commands described in paragraph 5.7.

When the instrument is in the remote mode (sending the ASCII character "!" causes the instrument to go to remote), the SERIAL interface input has priority over any front panel control. Therefore, as long as the SERIAL interface is continuously supplied with data, the front panel keys appear to be inoperative to the user.

@ The "at" symbol sets echo on. This command is used for RS 232 C only. @ is an action command, that is a carriage return <CR> is not needed.

Λ The carat puts the Model 52 into the non-echo mode. The unit remains in this mode until the next power down or an @ is received.

5.8.4 RS-232-C Error Codes

The Models 51 and 52 return the following error strings.

E1 Bad command or syntax.

E2 Bad numeric entry.

E3 Illegal channel number.

E4 Channel list or Program name already exists.

E5 Can not find the Channel list or Program.

E6 Out of memory.

E7 Program in process. User must terminate the program before the unit will accept remote commands.

E8 Channel number not present in the channel list, or no new measurements have been taken.

5.8.5 Interconnecting Cables

The configuration of the unit can be changed to DTE or DCE by switching an internal header (see paragraph 2.3.4). Or, the unit can be connected to a device using cables wired as "modem eliminators". At its simplest, two way (duplex) transmission requires that only three wires be connected to the Model 51 or 52:

Pin 2 Transmit Data (TXD)

Pin 3 Receive Data (RXD)

Pin 7 Signal Ground (SIG GND)

Several types of cables are shown in paragraph 2.3.4.

NOTE

The unit, if it is on, normally asserts pin 5 (CTS) if DCE-configured, or pin 20 (DTR) if DTE-configured. It can not assert these pins, of course, if it is off. A computer is often set up to verify that these lines are asserted before data can be sent from the computer. But the Models 51 and 52: A battery-saving design that can be "powered up" after receiving a character over the RS-232 bus. Some computers (DTE) have no soft or hard selection to make them not look at pin 5, CTS. This means that as long as pin 5 from the Model 51 or 52 is connected to them, they will not have the capability of sending the first character that turns on the unit. Deadlock. If you want this RS-232 Auto Pwr feature, the solution is to disconnect pin 5 coming from the Model 51 or 52; Since the computer must have incoming CTS asserted, use its outgoing RTS (pin 4) as a source of pullup. Loop the computer's pin 4 across to its pin 5. Pin 4 can also still feed across to the Model 51 or 52, if hardware handshaking is desired.

5.8.6 Handshaking

It is usually necessary to refer to the manuals for both of the devices being connected to determine the exact pin out, signal definition, and signal direction for the devices.

Handshaking is used so that the other device can tell the Model 51 or 52 when it is ready or not ready to receive data. The unit supports two types of handshaking: XON/XOFF (software handshaking), and CTS/DTR (hardware handshaking).

With XON/XOFF handshaking, the device receiving data from the Model 51 or 52 sends an XOFF ($13) over the appropriate data line when it is no longer ready to receive data, then sends an XON ($11) when it is again ready. When a Model 51 or 52 receives an XOFF character, it will send a maximum of 3 characters before it stops transmitting and waits to receive an XON character. The Model 51 or 52 always looks for XOFF/XON when it is transmitting. (There is no command to disable XOFF/XON.)

When it is receiving, the Model 51 or 52 sends an XOFF when its buffer is three-quarters full. The Model 51 or 52 receive buffer is 256 characters deep. The units can generally keep up with data received at 300 baud. At 9600 baud, and with long strings sent to them, the units may not return XOFF fast enought to prevent buffer overflow. An example of a string that may cause this is sending 64 lists to the units with no pause. Use of CTS is recommended for such high speed data-intensive transfers.

Hardware handshaking can be enabled or ignored by the selection in the RS-232-C main menu called CTS/DTR. CTS/DTR usage means that the line by that name coming from the data-receiving device must be asserted (positive) before the sending unit will transmit.

With this hardware handshaking, when the DTR signal (Model 51 and 52 DCE-configured pin 20) or CTS signal (Model 51 and 52 DTE-configured pin 5) line is pulled negative by a receiver, the 51 or 52 will send a maximum of one character before it stops transmitting and waits for the handshake line to return positive (asserted again).

And, when the 51 or 52 is the receiver, CTS (Model 51 and 52 DCE-configured pin 5) is normally asserted when the unit is on. The exception is when CTS/DTR is enabled, and the receive buffer is full. In that case the line will go false until the Model 51 or 52 is ready for more data.

5.8.7 Character Types

There are six types of characters that can be sent over the RS-232-C interface. These are:

Alphabetic characters — "A" through "Z". These are used in commands and mnemonics. Both upper and lower case characters are accepted.

Numeric characters (suffix) — These are "0" through "9", "-" (minus), "+" (plus), and the decimal point.

Interface Control Characters — These are "!", "@", Λ, "XON" ($11), and "XOFF" ($13).

Terminators — Designate the end of an character string. The Model 52 will accept a <CR>, <LF>, and <CR + LF>.

Syntax characters such as ":", ";", and <cr>. See paragraph 5.4.

5.9 RS-232-C BACKGROUND INFORMATION

EIA standard RS-232-C specifies the electrical characteristics and pin out of a serial communication standard for connecting "data terminal equipment" (DTE) to "data communication equipment" (DCE).

The RS-232-C standard describes only the recommended electrical, mechanical, and functional characteristics. Protocol and character codes are not universally defined.

RS-232-C signal lines defined as inputs on a DCE device are outputs on a DTE device and vice versa. Data Terminal Equipment (DTE) has its TXD (transmit data) line on pin 2. An example of a DTE device is a computer. DCE equipment also calls pin 2 TXD, even though it receives on pin 2.

Data Communication Equipment (DCE) converts data to another form and passes it on. It transmits on pin 3, even though pin 3 is called RXD (receive data) at both ends. Keep in mind that a line name was always from the point of view (historically) of the computer (DTE).

In the early history of RS-232, a modem was always a DCE device. Unfortunately, conventions such as this have not been adhered to over the years.

Transmission Mode

In asynchronous transmission, the receiver is synchronized to the transmitter on a character-by-character basis. An ASCII character (usually ASCII) is transmitted in serial, least significant bit first. This ASCII character comes after a start bit, and before one or two stop bits. The start bit of a minimum duration is required for the receiver to know that the following bit time contains a valid data bit. The receiver will start clocking in the middle of that first data bit, and each data bit thereafter.

The data is clocked into a serial-in, parallel-out shift register. Often, an I.C. called a UART is used for this purpose. The transmitter and receiver supply their own clocks, but the clock frequencies at each end ("baud rates") must be within about 5%.

Start Bit — Marks the beginning of the frame.
Data Bits — Represent the character.
Stop Bit — Marks the end of a frame.

State	Space	Mark
Data interpretation	0	1
Voltage level	+3 to +15V	−3 to −15V
Handshake control line interpretation	True	False

When no data is being transmitted (the idle state), the data lines sit in the mark state. To transmit a byte, the transmitting device first sends a start bit (space-level), for one bit time (1/baud rate) to synchronize the receiver. Next, the data bits are sent least significant bit (LSB) first and most significant bit (MSB) last. Finally the transmitting device sends at least one stop bit (a mark) before beginning the transmission of the next byte; the Models 51 and 52 use one stop bit. Some devices use an optional parity bit between the data bits and the stop bits; (the Models 51 and 52 do not).

Baud Rate

Baud rate is the bit rate during the transmission of a word, in bits per second. The two devices that are connected must be set to the same baud rate.

Handshaking

The RS-232 handshaking was originally specified with the expectation that a modem would be one of the devices. The specification has become "looser" in the sense that people now use it to "apply" to devices where neither one is a modem. A modem has several status-lines that a non-modem device does not need. The freeing up of these pins, which have become used for non-standard (in RS-232 terms) uses, has created a grey area.

5.10 IEEE-488 INFORMATION SPECIFIC TO MODELS 51 AND 52

5.10.1 Protocol and Handshaking

The Model 51 and 52 IEEE-488 software tries to prevent the hanging up of the interface bus. The Models 51 and 52 transmit *END at the end of text transmission. Thus, the controller recognizes the text has ended and the Model 51 or 52 is not requesting more information. These termination characters (*END) do not apply to error strings, transmission of alarms, or information transmitted in the continuous mode. If the controller has not requested the next text string from the Model 51 or 52 by the time the information is available, the Model 51 or 52 asserts the SRQ line. Retrieving information by servicing the SRQ is often the best method. If the Model 51 or 52 has no data, a zero is stored in the status byte. When there is data, a one is stored in the status byte.

5.10.2 Manually Setting the IEEE-488 Options

The IEEE-488 options can be set from the front panel.

1. Select IEEE-488 from the main menu. Hint: press **Func**.

IEEE-488
<RECEIVE OFF>
<XMIT
ADDR 09▲ ▼

2. Select the options.

Item	Description
RECEIVE	Sets the unit for IEEE-488 receive.
XMIT	Sets the unit for IEEE-488 transmit.
OFF	Turns off IEEE-488.
ADDR	Use the ▲ ▼ cursor keys to select the unit's address. Valid addresses are 1 through 31.

To both transmit and receive over IEEE-488, select both RECEIVE and XMIT.

To change the GPIB options remotely, see paragraph 5.7.16.

5.10.3 GPIB Commands

GPIB commands are divided into five classes.

5.10.3.1 Listen Address

Listen addresses are used to command a device to read any data bytes transmitted over lines DI01-DI08. There are 30 different available addresses. Address 32, called unlisten (hexadecimal "3F", ASCII "?") commands all devices to not read data bytes. The low order five bits of the unit's listen address are selected by an internal DIP switch (see section 2), or the GPIB main menu item, or remotely (paragraph 4.7.16).

5.10.3.2 Talk Address

Talk address commands a device to transmit data over lines DO01-DI08. There are 30 different available addresses. Address 32, called untalk, (hexadecimal "5F', ASCII "_" commands all devices to cease talking. The lower order five bits of the unit's talk address will be the same as the low order five bits of the listen address. Thus, if the listen address is hexadecimal 21 the talk address is hexadecimal 41.

5.10.3.3 Secondary Address

A secondary address follows a talk or listen address and provides the ability to address more than 31 devices provided for by a simple talk or listen address. The Models 51 and 52 ignore secondary addresses.

5.10.3.4 Universal Commands

Universal commands tell a device to perform designated actions. The Model 52 ignores all universal commands. The Model 51 responds to parallel poll, parallel poll configure, and parallel poll unconfigure.

5.10.3.5 Addressed Commands

Addressed commands tell a device to perform designated actions. The Models 51 and 52 recognize the addressed command GTL (for Models 51 and 52 use GOTO LOCL) only when addressed as a listener. GOTO LOCL puts the Model 52 in the local mode.

5.10.4 Data Transfer

In addition to accepting programming characters, the unit transmits data over the bus. To program the instrument, first send the listen address (ATN on), followed by the programming data (in ASCII, ATN off). The instrument accepts data as fast as possible (at approximately 120μs/character), until either 64 characters are received or there is a pause during the transfer of data. At this time, the entire string of received characters is scanned by the Model 51 or 52, which carries out the scan and accepts the next 64 character string.

5.10.5 Interface Functions Implemented

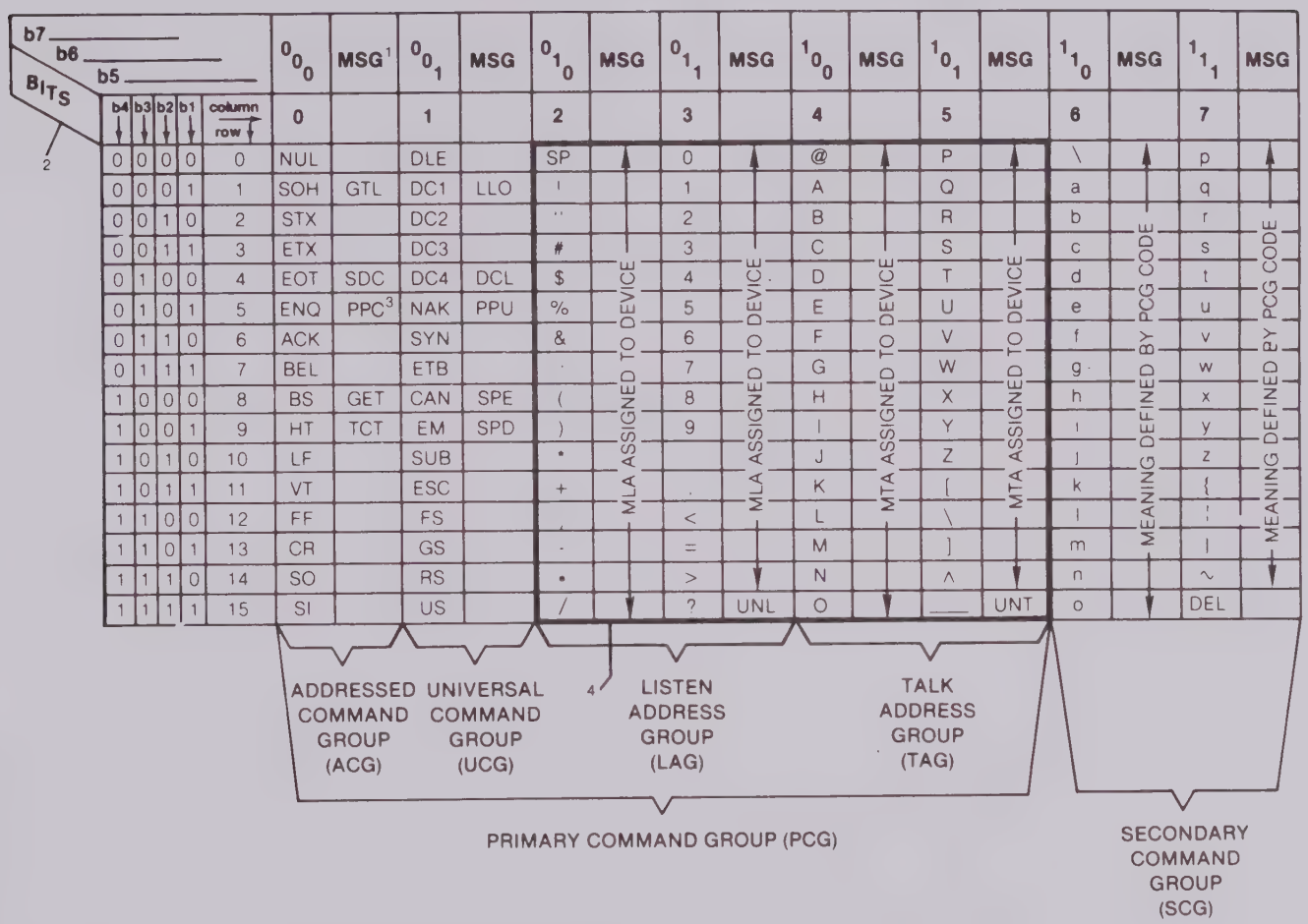
The Model 52 supports the following interface functions:

SH1	Complete source handshake.
AH1	Complete acceptor handshake/
T6	Basic talker.
TE0	No extended talker.
L4	Basic listener.
SR1	Complete service request (software select).
RL1	Remote/local and local lockout.
PP0	No parallel poll capability. (Model 52.)
DC1	Complete device clear/selective device clear.
DT1	Complete device trigger capability.
E1	Tri-state drivers.

The Model 51 supports the following interface functions:

SH1	Complete source handshake.
AH1	Complete acceptor handshake/
T5	Full talker.
TE0	No extended talker.
L3	Full listen.
SR1	Complete service request (software select).
PP1	Parallel poll capability.
DC1	Complete device clear/selective device clear.
DT1	Complete device trigger capability.
E1	Tri-state drivers.

APPENDIX A
AMERICAN STANDARD CODE FOR INFORMATION INTERCHANGE (ASCII)



b4	b3	b2	b1	column / row	0_0	MSG[1]	0_1	MSG	$0_1{}_0$	MSG	$0_1{}_1$	MSG	$1_0{}_0$	MSG	$1_0{}_1$	MSG	$1_1{}_0$	MSG	$1_1{}_1$	MSG
					0		1		2		3		4		5		6		7	
0	0	0	0	0	NUL		DLE		SP		0		@		P		\		p	
0	0	0	1	1	SOH	GTL	DC1	LLO	!		1		A		Q		a		q	
0	0	1	0	2	STX		DC2		"		2		B		R		b		r	
0	0	1	1	3	ETX		DC3		#		3		C		S		c		s	
0	1	0	0	4	EOT	SDC	DC4	DCL	$		4		D		T		d		t	
0	1	0	1	5	ENQ	PPC[3]	NAK	PPU	%		5		E		U		e		u	
0	1	1	0	6	ACK		SYN		&		6		F		V		f		v	
0	1	1	1	7	BEL		ETB		'		7		G		W		g		w	
1	0	0	0	8	BS	GET	CAN	SPE	(		8		H		X		h		x	
1	0	0	1	9	HT	TCT	EM	SPD	)		9		I		Y		i		y	
1	0	1	0	10	LF		SUB		*		:		J		Z		j		z	
1	0	1	1	11	VT		ESC		+		;		K		[		k		{	
1	1	0	0	12	FF		FS		,		<		L		\		l		|	
1	1	0	1	13	CR		GS		-		=		M		]		m		}	
1	1	1	0	14	SO		RS		.		>		N		^		n		~	
1	1	1	1	15	SI		US		/		?	UNL	O		_	UNT	o		DEL	

[1]MSG = INTERFACE MESSAGE
[2]b1 = DIO1 . . . b7 = DIO7
[3]REQUIRES SECONDARY COMMAND
[4]DENSE SUBSET (COLUMN 2 THROUGH 5)

DC4	=	DCL	Device clear
DC1	=	LLO	Local lockout
NAK	=	PPU	Parallel poll unconfigure
EM	=	SPD	Serial poll disable
CAN	=	SPE	Serial poll enable

Universal Command Group

SOH	=	GTL	Go to local
EOT	=	SDC	Selected device clear
ENQ	=	PPC	Parallel poll configure
BS	=	GET	Group execute trigger
HT	=	TCT	Take control

Addressed Command Group

APPENDIX B
REMOTE COMMAND SUMMARY

Command	Description	Reference Paragraph	Local MENU/ Action
@	Places unit in received character echo mode (default condition)	5.7.1	—
^	Places unit in non-echo mode	5.7.2	—
!	Places the Model 52 in remote	5.7.3	—
ALRM	Create an alarm channel	5.7.4	ALARMS
BIN LOAD	Loads a channel list or program	5.7.5	—
BOUT	Transmits a named channel list or program	5.7.6	—
CAL	Calibrates a given channel, function, and range	5.7.7	Selecting CAL function mod.
DATA	Sets transmit and storage selections, by data type	5.7.8	DATA ROUTING
DATE	Sets the unit's date	5.7.9	TIME/DATE
DEL	Deletes a named channel list or program from the unit's memory	5.7.10	Find Name.L/P, then DELETE
DIR	Transmits the directory of existing channel lists and programs	5.7.11	—
DISP DIS	Disables the Model 52 display	5.7.12	DISPLAY MODE
DISP ENAB	Enables the Model 52 display	5.7.12	DISPLAY MODE
ENTL	Creates a channel list	5.7.13	CHANNEL LIST
ENTP	Creates a program	5.7.14	PROGRAM
GOTO FPOF	Disables front panel key execution	5.7.15	KEYBOARD LOCK
GOTO FPON	Enables front panel keys to function in parallel with remote commands	5.7.15	—
GOTO LLO	Locks out the front panel	5.7.15	KEYBOARD LOCK
GOTO LOCL	Returns to front panel control	5.7.15	Entering code
GPIB	Sets the IEEE-488 communication options	5.7.16	IEEE-488
INIT	Resets the unit (clears data memory, programs, and channel lists)	5.7.17	Power-on-Clear
MATH	Creates a math channel formula	5.7.18	MATH
MON	Sets the monitor mode conditions	5.7.19	MONITOR MODE
POFF	Shuts off the unit's power	5.7.20	Power button
R232	Sets the RS-232-C communications options	5.7.21	RS-232-C
READ	Reads data from any entry in a currently running channel list	5.7.22	Scrolling
RCL	Displays, transmits, or clears data from memory	5.7.23	RECALL DATA
RUN	Runs an existing program or channel list	5.7.24	Find NAME.L/P select **R**
STAT	Sets line reject frequency and power save mode	5.7.25	UNIT STATUS
STOP	Terminates a running program	5.7.26	MENU key
TIME	Sets the unit's real time clock	5.7.27	TIME/DATE
TRAK	Sets tracking parameters	5.7.28	TRACKING
WR	Writes decimal value to an output channel	5.7.29	DMM, enter ch#, function, etc.
XMIT	Sets transmission conditions; Memory management	5.7.30	TRANSMIT/MEM
CNF?	Model 51 only. Tells options installed and software version	5.7.31	CONFIGURATION
DT?	Model 51 only. Tells date and time	5.7.32	Measuring ch. 9 in DMM mode
ID?	Model 51 only. Tells software version	5.7.33	CONFIGURATION
MEM?	Model 51 only. Tells amount of storage memory left	5.7.34	MEMORY STATUS

APPENDIX C
SELECTING DATA TYPES TO BE STORED

(Taking Data Continuously)	Data Type	Use
	1) Store always, normal or abnormal, data.	Channel list + **DATA** SLST
(Items 1-4 deal with sorting data within a channel.)	2) Store only abnormal data. (See figure C1.)	Channel list + **DATA** SALR + alarm (usually use OWIN)
	3) Store only normal data. (Call normal data (inside range) "alarm data". See figure C2.)	Channel list + **DATA** SALR + alarm (usually use IWIN)
	4) Store neither kind (normal/abnormal) of data.	Channel list + **DATA** NONE
	5) Two or more channels taking measurements. All except for one are to be logged regularly. One channel is never to be logged (but perhaps displayed or transmitted with the rest).	Channel list inside a program + monitor list
(Items 5-7 deal with distinguishing which channels are to be logged.)	6) Two or more channels taking measurements. All except for one are to be logged regularly. One may or may not be logged, depending on alarm condition.	Use channel list/s inside a program + monitor list with alarm
	7) Several (two or more) measurement channels. Only one to be logged. That one to be regularly logged.	Use channel list inside program + monitor list. (All channels not to be logged are inside monitor list.)
	8) Another way to accomplish (5,6,7) sometimes: Sort them by alarms. Attach alarms only to the measurement/s you want to store, and set the thresholds such that the alarms are always true.	Channel list + **DATA** SALR

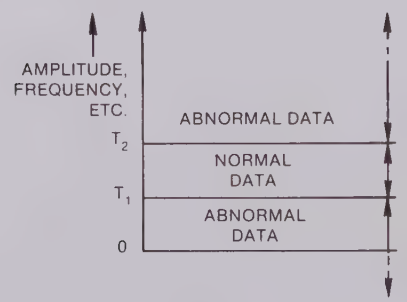


Figure C1.

Figure C2.

APPENDIX D
SUMMARY OF MAIN MENU ITEMS

Main Menu Item	Reference Paragraph	"Quick" Display Key*	Result of Selecting the Item
<DMM	4.5	Menu	Allows measurement of a single input signal.
<CHANNEL LIST	4.6	Menu	Allows creation of a channel list, which measures several things at the same time.
<PROGRAM	4.7	Menu	Allows creation of a program that uses existing channel lists to make measurements. Programs include start time, channel list(s), list repetition, intervals, and stop time.
<RECALL DATA	4.4.3	Menu	Allows displaying, transmitting, and deleting of the readings stored in memory. Readings can be sorted by channel number, scan number, time, or alarm number.
<DISPLAY MODE	4.3.1	Disp	Allows selection of how readings are shown.
<MONITOR MODE	4.7.3	Disp	Allows selection of the Model 52 operation between program scans.
<KEYBOARD LOCK	4.3.2	Disp	Allows user-set code to lockout keyboard. Requires user to enter code to use keyboard.
<TIME/DATE	4.5.1.3	Disp	Allows setting of time and date of real time clock.
<MATH	4.3.7	Mods	Allows entry of up to 99 user-defined formulas.
<ALARMS	4.5.5.2	Mods	Allows setting of thresholds and responses of up to 31 setups.
<TRACKING	4.5.5.3	Mods	Allows setting zero and full scale values for 4 digital and 4 analog outputs for tracking (channels 5 – 8).
<UNIT STATUS	4.3.5	Mods or Range	Displays last calibration date and selects power save option and 50/60 Hz operation.
<MEMORY STATUS	4.3.3	Range	Displays free RAM, data and program usage in bytes.
<CONFIGURATION	4.3.4	Range	Displays the software revision number, measurement modules, digital I/O cards, memory card, and interface items installed in unit.

*Calls the item to the screen (but does not "select" it). Use these keys to quickly move from one display to another.

APPENDIX D

SUMMARY OF MAIN MENU ITEMS (Continued)

Main Menu Item	Reference Paragraph	"Quick" Display Key*	Result of Selecting the Item
<DATA ROUTING	4.4.1	Range or Func	Allows selection of transmission or storage of readings from channel lists, programs, and alarms.
<TRANSMIT/MEM	4.4.2	Func	Allows selection of when readings are transmitted and how the memory is filled.
<IEEE-488	5.10	Func	Allows setting up IEEE-488 operating conditions including address.
<RS-232-C	5.8	Func	Allows setting up RS-232-C operating conditions including Baud rate.
<TEMP.L R>	4.6	Chan or ± •	A sample of a typical stored channel list.
<MONITOR.L R>	4.6	Chan	A sample of a typical stored channel list.
<RES-TOL.L R>	4.6	Chan	A sample of a typical stored channel list.
<LOGGER.P R>	4.7	Chan	A sample of a typical stored program.

*Calls the item to the screen (but does not "select" it). Use these keys to quickly move from one display to another

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